United States
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Region III
Chesapeake Bay Program Office

Biological Evaluation for the Issuance of Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries

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Biological Evaluation

for the Issuance of *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll* a *for the Chesapeake Bay and Its Tidal Tributaries*

April 25, 2003

U.S. Environmental Protection Agency
Region III

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Appendices

Biological Evaluation for the Issuance of Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll *a* for the Chesapeake Bay and Its Tidal Tributaries

U.S. Environmental Protection Agency Region III

April 2003

The U.S. Environmental Protection Agency's (EPA) Region III *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries (Regional Criteria Guidance)* is being evaluated. The EPA is voluntarily continuing consultation with NOAA National Marine Fisheries Service in accordance with Section 7 of the Endangered Species Act by issuing this biological evaluation.

The NOAA National Marine Fisheries Service, which is the federal agency with responsibility for the shortnose sturgeon (*Acipenser brevirostrum*) under the Endangered Species Act (ESA), has advised the EPA that shortnose sturgeon have been documented in various areas of the Chesapeake Bay and its tidal tributaries and are, therefore, considered to be present in the Bay.

BACKGROUND

The Administrator of the U.S. Environmental Protection Agency (EPA); the governors of Maryland, Virginia and Pennsylvania; the Mayor of the District of Columbia; and the Chair of a tri-state legislative body known as the Chesapeake Bay Commission signed the *Chesapeake Bay Agreement* in 1987 (Chesapeake Executive Council 1987). A principal goal of that agreement was a 40 percent reduction of nutrients (nitrogen and phosphorus) entering the Bay tidal waters by the year 2000 from controllable point and nonpoint sources in the entire 64,000-square-mile Bay watershed from levels being discharged in 1985. The agreement provided that once achieved, this level would be maintained thereafter. Implementation of this goal was conducted in a cooperative manner including actions under state laws primarily for best management practice (BMP) implementation, and voluntary reductions from both point and nonpoint sources encouraged by cost share grant programs. The EPA is participating in these activities pursuant to Section 117 of the Clean Water Act.

Yet in spite of these efforts, nutrient and sediment enrichment related water quality problems have persisted throughout the Chesapeake Bay and tidal tributaries (Figure 1) (U.S. Environmental Protection Agency 2003b). Maryland's portion of the Chesapeake Bay and its tidal tributaries were listed on its 1996 and 1998 Clean Water Act (CWA) Section 303(d) lists of impaired waters. In May 1999, EPA Region III identified Virginia's portion of the Chesapeake Bay and portions of several tidal tributaries on Virginia's 1998 CWA Section 303(d) list. Delaware's tidal portion of the Nanticoke River and the District of Columbia's tidal Anacostia

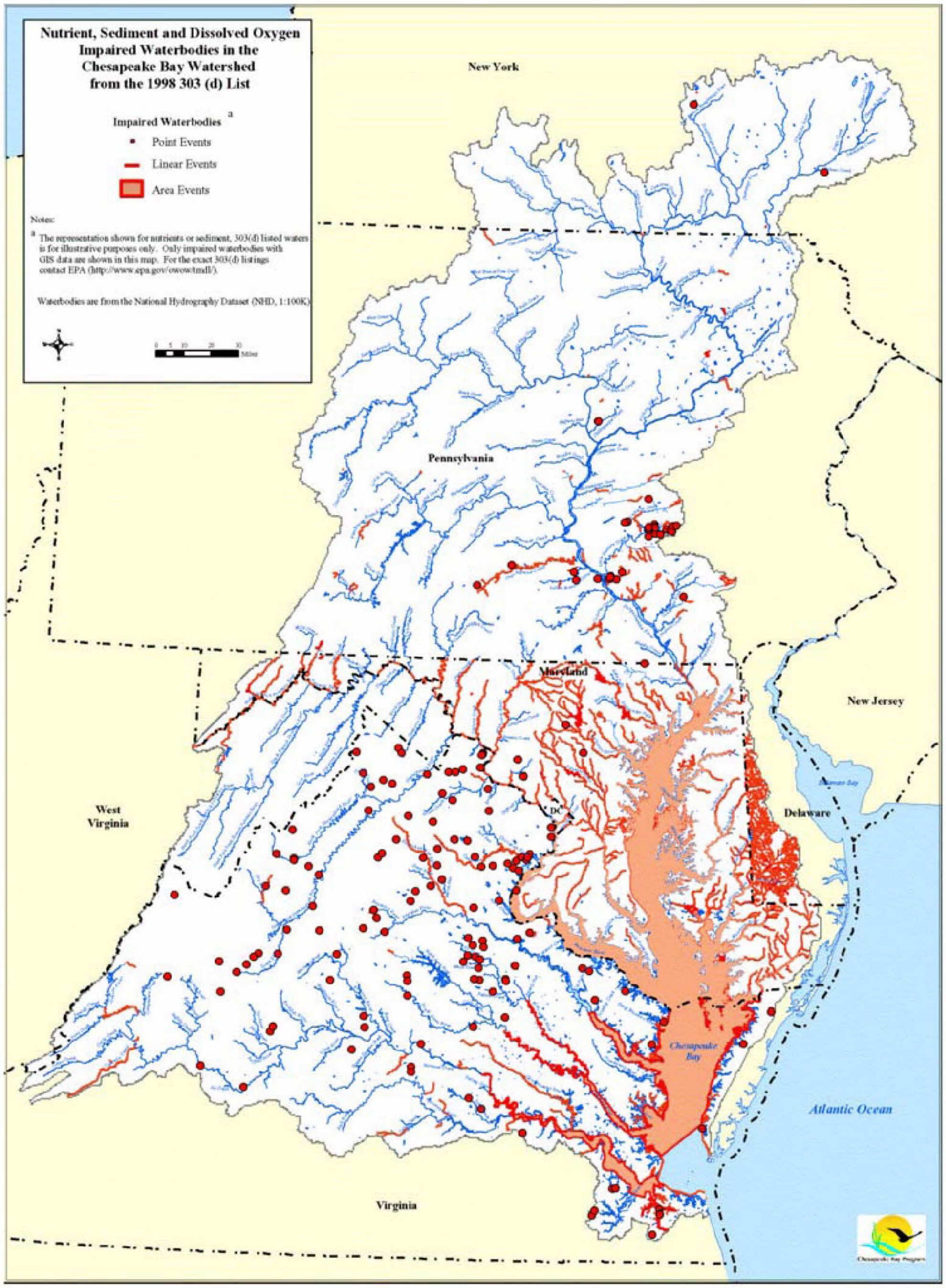

Figure 1. Illustration of the nutrient, sediment and dissolved oxygen impaired waterbodies in the Chesapeake Bay watershed from 1998 303(d) list.

Source: U.S. EPA http://www.epa.gov/owow/tmdl/

and Potomac rivers have also been listed on the Section 303(d) list. Shortly thereafter, a new agreement, entitled *Chesapeake 2000* was adopted by the Chesapeake Bay Executive Council in response to a comprehensive assessment of the Bay's restoration needs and delineated an ambitious list of new restoration commitments (Chesapeake Executive Council 2000). New York, Delaware and West Virginia have been brought in as watershed partners committed to these Chesapeake Bay water quality restoration goals through a six state memorandum of understanding with the EPA (Chesapeake Bay Watershed Partners 2001).

Chesapeake 2000 lists the following specific actions as steps to achieve its water quality goals for nutrients and sediment:

1. By 2001, define water quality conditions (i.e., criteria) necessary to protect aquatic living resources and then assign load reductions for nitrogen, phosphorus and sediment to each major tributary;

2. By 2002, complete a public process to develop and begin implementation of revised Tributary Strategies to achieve and maintain the assigned loading goals;

3. By 2003, the jurisdictions with tidal waters will use their best efforts to adopt new or revised water quality standards consistent with the defined water quality conditions.

Note that, though the actions still apply, the schedule has changed as follows:

- Final definitions of water quality conditions (i.e., criteria)–April 2003;
- Complete revisions to tributary strategies–April 2004; and
- Adoption of revised water quality standards–July 2005.

To implement and coordinate the above actions, the Chesapeake Bay Program formed a Water Quality Steering Committee composed of senior water management policy representatives from all seven watershed jurisdictions–New York, Pennsylvania, Maryland, District of Columbia, Delaware, Virginia and West Virginia–EPA Region II, Region III and Headquarters, Chesapeake Bay Commission, Interstate Commission on the Potomac River Basin, and the Susquehanna River Basin Commission. A wide range of stakeholders including: regional governmental organizations, the environmental advocacy community and wastewater treatment facility owners and operators actively participated with the Committee. These partners and stakeholders have been meeting several times a month over the past three years to meet the water quality commitments set forth in *Chesapeake 2000*.

The "water quality conditions necessary to protect aquatic living resources" are being defined through the development of EPA guidance for Chesapeake Bay specific water quality criteria for dissolved oxygen, water clarity and chlorophyll *a* under the direction of the Chesapeake Bay Program's Water Quality Steering Committee. Collectively, the EPA believes these three water quality parameters provide the best and most direct measures of the impacts of too much nutrient and sediment pollution on the Bay's aquatic living resources–fish, crabs, oysters, and underwater bay grasses. The criteria are being published by EPA Region III as Chesapeake Bay specific water quality criteria guidance (U.S. Environmental Protection Agency 2003a).

The criteria are being issued pursuant to the Chesapeake Bay Program's statutory mandate under Section 117 (b)(2)(B) of the Clean Water Act to "implement and coordinate science, research, modeling, support services, monitoring, data collection and other activities that support the Chesapeake Bay Program." These criteria provide EPA's recommendations to states for use in establishing water quality standards consistent with Section 303 (c) of the Clean Water Act, focusing on the recovery and protection of aquatic life resources.

SUMMARY OF THE PROPOSED *REGIONAL CRITERIA GUIDANCE*

In order to achieve and maintain the water quality conditions necessary to protect the aquatic living resources of the Chesapeake Bay and its tidal tributaries, EPA Region III has developed the *Regional Criteria Guidance*. The EPA is issuing this guidance in accordance with Section 117(b) of the Clean Water Act and in accordance with the water quality standards regulations (40 CFR Part B1). This document presents EPA's regionally-based nutrient and sediment enrichment criteria expressed as dissolved oxygen, water clarity and chlorophyll *a* criteria, applicable to the Chesapeake Bay and its tidal tributaries. This guidance is intended to assist the Chesapeake Bay states, Maryland, Virginia and Delaware, and the District of Columbia in adopting revised water quality standards to address nutrient and sediment-based pollution in the Chesapeake Bay and its tidal tributaries.

EPA Region III has identified and described five habitats (or designated uses) that, when adequately protected, will ensure the protection of the living resources of the Chesapeake Bay and tidal tributaries. Those five uses (summarized below and described in detail in Appendix A and B) provide the context in which EPA Region III derived adequately protective Chesapeake Bay water quality criteria for dissolved oxygen, water clarity and chlorophyll *a*, which are the subject of the *Regional Criteria Guidance*. Accurate delineation of where to apply these tidal water designated uses is critical to the Chesapeake Bay water quality criteria (U.S. Environmental Protection Agency 2003a).

The Chesapeake Bay dissolved oxygen criteria vary significantly across the five refined tidal water designated uses to fully reflect the wide array of species living in these different Bay habitats, as reflected in Table 1.

The water clarity criteria reflect the different light requirements for underwater plant communities that inhabit low salinity versus higher salinity shallow water habitats throughout the Bay and its tidal tributaries. Table 2 provides an overview of the recommended light requirements for water clarity criteria.

The EPA is providing the states with a recommended narrative chlorophyll *a* criteria applicable to all Chesapeake Bay and tidal tributary waters (Table 3). The EPA encourages the states to adopt numerical chlorophyll *a* criteria for application to those tidal waters where algal related designated use impairments are likely to persist even after attainment of the applicable dissolved oxygen and water clarity criteria. The *Regional Criteria Guidance* contains technical information to support quantitative interpretation of the narrative chlorophyll *a* criteria.

The *Regional Criteria Guidance* is the product of a collaborative effort among the Chesapeake Bay Program partners. They represent a scientific consensus based on the best available scientific findings and technical information defining water quality conditions necessary to protect Chesapeake Bay aquatic living resources from effects due to nutrient and sediment over-enrichment. Various stakeholder groups have been involved in their development, with contributions from staff of federal and state government, local agencies, scientific institutions, citizen conservation groups, business and industry.

The EPA conducted three reviews of the *Regional Criteria Guidance*. The third and final public review of the *Regional Criteria Guidance* document was completed in January 2003 in parallel to the second and final independent scientific peer review. The *Regional Criteria Guidance*, comments from reviewers and responses to reviewers' comments will be available on the web on April 25, 2003 at: http://www.chesapeakebay.net/baycriteria.htm. A full copy of the *Regional Criteria Guidance* is attached as Appendix A.

In addition to the *Regional Criteria Guidance*, EPA Region III distributed a draft *Technical Support Document for the Identification of Chesapeake Bay Designated Uses and Attainability (Technical Support Document)* for public review. The *Technical Support Document* provides additional information for states to consider in the refinement of designated uses and modifications of state water quality standards.

The *Technical Support Document* was made available for review and comment on December 16, 2002. Comments received and response to reviewers' comments are available on the web at: http://www.chesapeakebay.net/baytsd.htm. A full copy of the *draft Technical Support Document* was included in the draft BE previously submitted to NOAA National Marine Fisheries and the U. S. Fish and Wildlife Service as part of the informal consultation. The final document is expected to be completed on May 30, 2003. A full copy will be provided, upon publication next month, as Appendix B.

WATER QUALITY STANDARDS

Water quality standards consist of 1) designated uses for the water body, 2) narrative or numerical water quality criteria to protect those uses, and 3) an anti-degradation policy. Currently, each state across the Chesapeake Bay and tidal tributary jurisdictional waters in the current Maryland, Virginia, Delaware and the District of Columbia designated aquatic life uses to be protected as part of their water quality standards. The *Regional Criteria Guidance* enables the states to consider more specific, and in general, more protective aquatic life use refinements into criteria. The Chesapeake Bay watershed states with tidally influenced Bay waters–Maryland, Virginia, Delaware and the District of Columbia–are ultimately responsible for defining and formally adopting a refined set of designated uses into their respective water quality standards.

New and Refined Tidal Water Designated Uses

The five new and refined Chesapeake Bay tidal water designated uses are proposed to more fully reflect the different aquatic living resources communities inhabiting a variety of habitats and, therefore, the different intended aquatic life uses of those tidal habitats. The tidal water designated uses provide the context for deriving the Chesapeake Bay dissolved oxygen, water clarity and chlorophyll *a* water quality criteria. Accurate delineation of where to apply these tidal water designated uses is critical to effective application of the Chesapeake Bay water quality criteria. See the *Technical Support Document* (U.S. Environmental Protection Agency 2003b) for a more detailed explanation of new and refined uses.

The ***migratory fish spawning and nursery designated use*** shall support the survival, growth and propagation of balanced indigenous populations of ecologically, recreationally and commercially important anadromous, semi-anadromous and tidal-fresh resident fish species, including the federally listed shortnose sturgeon, inhabiting spawning and nursery grounds from February 1 through May 31. It protects migratory fish during the late winter to spring spawning and nursery season in tidal freshwater to low-salinity habitats. Located primarily in the upper reaches of many Bay tidal rivers and creeks and the upper mainstem Chesapeake Bay, this use will benefit several species including striped bass, perch, shad, herring and sturgeon.

The ***shallow-water bay grass designated use*** shall support the survival, growth and propagation of rooted, underwater bay grasses necessary for the propagation and growth of balanced, indigenous populations of ecologically, recreationally and commercially important fish and shellfish inhabiting vegetated shallow-water habitats.

The ***open-water fish and shellfish designated use*** shall support the survival, growth and of balanced, indigenous populations of ecologically, recreationally, and commercially important fish and shellfish species inhabiting open water habitats. It is focused on surface-water habitats in tidal creeks, rivers, embayments and the mainstem Bay, and protects diverse populations of sportfish, including striped bass, bluefish, mackerel and sea trout, as well as important bait fish such as federally listed shortnose sturgeon and important bait fish such as menhaden and silversides.

The ***deep-water seasonal fish and shellfish designated use*** shall support the survival, growth and propagation of balanced, indigenous populations of ecologically, recreationally, and commercially important fish and shellfish species inhabiting deep-water habitats from June through September. It protects animals inhabiting the deeper transitional water-column and bottom habitats between the well-mixed surface waters and the very deep channels. This use protects many bottom-feeding fish, crabs and oysters, and other important species such as the bay anchovy.

The ***deep-channel seasonal refuge designated use*** shall protect the survival of balanced, indigenous populations of ecologically important benthic infaunal and epifaunal worms and clams, which provide food for bottom-feeding fish and crabs from June through September. Naturally low dissolved oxygen conditions prevail in the deepest portions of this habitat zone, during the summer.

Chesapeake Bay Water Quality Criteria

Dissolved Oxygen Criteria

Current numeric state water quality criteria for tidal Chesapeake Bay waters aquatic life protection require 5 mg liter $^{-1}$ dissolved oxygen concentrations at all times (instantaneous or daily minimum) throughout the year throughout all of tidal Bay waters – from the deep trench extending down the center of the mainstem Chesapeake Bay to the shallows lining thousands of miles of shoreline. Based on in-depth analyses of natural conditions and human-caused conditions that can not be remedied, there are portions of deep-water Chesapeake Bay and its tidal tributaries that can not achieve the current state dissolved oxygen standards during the June 1 through September 30 time frame (U.S. Environmental Protection Agency 2003b). Based on the scientific information set forth in the *Regional Criteria Guidance* and the *Technical Support Document*, the EPA has found that the aquatic life uses in the deep-water and deep-channel habitats (summer only) have not and will not require a 5 mg liter $^{-1}$ dissolved oxygen levels for protection (see Appendix A and B and discussions below). At the same time, the EPA found that migratory fish spawning and nursery habitats require higher levels of dissolved oxygen (>5 mg liter $^{-1}$) to sustain aquatic life use during the late winter to early summer time frame than provided by the current state water quality standards. The Chesapeake Bay dissolved oxygen criteria are based on the clear scientific evaluations of the specific needs of the aquatic living resources, where they live, and during which time of the year they live there (the designated uses or habitats) and the level of oxygen needed within each of the designated uses of the Bay tidal waters.

The Chesapeake Bay dissolved oxygen criteria vary significantly across the five refined tidal water designated uses to fully reflect the wide array of species living in these different Bay habitats. Table 1 summarizes the Chesapeake Bay dissolved oxygen criteria. For more detailed information, including scientific data used in the development of the criteria, please review Chapter III in the *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll A for the Chesapeake Bay and Its Tidal Tributaries* (Appendix A; U.S. Environmental Protection Agency 2003a). To review the recommended implementation procedures for this criteria, see Chapter VI in the same document.

Water Clarity

Currently there are no numeric state water quality criteria that exist for water clarity with the exception of the District of Columbia. The primary causes that have contributed to the loss of underwater bay grasses in the Chesapeake Bay are nutrient over-enrichment and increased suspended sediments in the water, and associated reductions in light availability. By applying appropriate numeric water clarity criteria to the shallow-water bay grass designated use, attainment of this criteria will improve the health and survival of underwater plant communities and, thus, the quality of life and diversity of the fish and invertebrate species supported by these shallow-water vegetated habitats (U.S. Environmental Protection Agency 2003a).

The *Technical Support Document* proposes that water clarity criteria should apply to varying depths from 0.5 meters up to 2 meters (approximately 6.5 feet) depending on the area of the Bay and tidal tributaries (U.S. Environmental Protection Agency 2003b). Areas where natural factors (e.g. strong currents, rocky bottoms, shipping terminals) or permanent physical alternations to shoreline (e.g., shipping terminals) would prevent underwater bay grass growth would be excluded (Appendix B; U.S. Environmental Protection Agency 2003b).

The water clarity criteria reflect the different light requirements for underwater plant communities that inhabit low salinity versus higher salinity shallow water habitats throughout the Bay and its tidal tributaries (Table 2). For more detailed information, including scientific data used in the development of the criteria, please review Chapter IV in the *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll A for the Chesapeake Bay and Its Tidal Tributaries* (Appendix A; U.S. Environmental Protection Agency 2003a). To review the recommended implementation procedures for this criteria, see Chapter VI in the same document.

Table 1. Chesapeake Bay dissolved oxygen criteria.

Designated Use	Criteria Concentration/ Duration	Protection Being Provided	Temporal Application
Migratory fish spawning and nursery use	7-day mean ≥ 6 mg $liter^{-1}$ (tidal habitats with 0-0.5 ppt salinity)	Survival/growth of larvae/juvenile tidal fresh resident fish; protective of threatened/endangered species.	February 1 -May 31
	Instantaneous minimum ≥ 5 mg $liter^{-1}$	Survival and growth of larvae/juvenile migratory fish; protective of threatened/endangered species.	
	Open water designated use criteria apply		June 1 - January 31
Shallow-water bay grass use	Open water designated use criteria apply		year-round
Open-water fish and shellfish use	30 day mean ≥ 5.5 mg $liter^{-1}$ (tidal habitats with 0-0.5 ppt salinity)	Growth of tidal fresh juvenile and adult fish; protective of threatened/endangered species.	year-round
	30 day mean ≥ 5 mg $liter^{-1}$ (tidal habitats with >0.5 ppt salinity)	Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species.	
	7 day mean ≥ 4 mg $liter^{-1}$	Survival of open-water fish larvae.	
	Instantaneous minimum ≥ 3.2 mg $liter^{-1}$	Survival of threatened/endangered sturgeon species.[1]	
Deep-water seasonal fish and shellfish use	30 day mean ≥ 3 mg $liter^{-1}$	Survival and growth of Bay anchovy eggs and larvae.	June 1 - September 30
	1 day mean ≥ 2.3 mg $liter^{-1}$	Survival of open-water juvenile and adult fish.	
	Instantaneous minimum ≥ 1.7 mg $liter^{-1}$	Survival of Bay anchovy eggs and larvae.	
	Open water designated use criteria apply		October 1 - May 31
Deep-channel seasonal refuge use	Instantaneous minimum ≥ 1 mg $liter^{-1}$	Survival of bottom-dwelling worms and clams.	June 1 - September 30
	Open water designated use criteria apply		October 1 - May 31

1. At temperatures considered stressful to shortnose sturgeon (>29°C), dissolved oxygen concentrations above an instantaneous minimum of 4.3 mg $liter^{-1}$ will protect survival of this listed sturgeon species.

Source: U.S. Environmental Protection Agency 2003a.

Table 2. Summary of Chesapeake Bay water clarity criteria for application to shallow-water bay grass designated use habitats.

Salinity Regime	Water Clarity Criteria as Percent Light-through-Water	Water Clarity Criteria as Secchi Depth								Temporal Application
		Water Clarity Criteria Application Depths								
		0.25	0.5	0.75	1.0	1.25	1.5	1.75	2.0	
		Secchi Depth (meters) for Above Criteria Application Depth								
Tidal fresh	13%	0.2	0.4	0.5	0.7	0.9	1.2	1.3	1.4	April 1 - October 31
Oligohaline	13%	0.2	0.4	0.5	0.7	0.9	1.2	1.3	1.4	April 1 - October 31
Mesohaline	22%	0.2	0.5	0.7	1.0	1.2	1.4	1.7	1.9	April 1 - October 31
Polyhaline	22%	0.2	0.5	0.7	1.0	1.2	1.4	1.7	1.9	March 1 - May 31, September 1 - November 30

Source: U.S. Environmental Protection Agency 2003a.

Chlorophyll *a*

Maryland, Virginia, Delaware and District of Columbia's current water quality standards do not include numeric chlorophyll *a* criteria. Chlorophyll *a* is an integrated measure of primary production as well as an indicator of water quality. Chlorophyll *a* plays a direct role in reducing light penetration in shallow-water habitat, thereby negatively affecting underwater bay grasses. Uneaten by zooplankton and filter feeding shellfish, the microbial process that breaks down excess dead algae removes oxygen from the water column. Phytoplankton assemblages can become dominated by single species which represent poor food quality or even produce toxins that impair the animals that feed directly on them. From a water quality perspective, chlorophyll *a* is the best available, most direct measure of the amount and quality of phytoplankton and the potential for reduced water clarity and low dissolved oxygen impairments.

The EPA is providing the states with a recommended narrative chlorophyll *a* criteria applicable to all Chesapeake Bay and tidal tributary waters (Table 3). The EPA encourages the states to adopt numerical chlorophyll *a* criteria for application to those tidal waters where algal related designated use impairments are likely to persist even after attainment of the applicable dissolved oxygen and water clarity criteria. The technical information supporting states' quantitative interpretation of the narrative chlorophyll *a* criteria is published within the body of the Chesapeake Bay water quality criteria document. For a full description and detailed technical supporting documentation, please review Chapter V in the *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll A for the Chesapeake Bay and Its Tidal Tributaries* (Appendix A; U.S. Environmental Protection Agency, 2003a). To review the recommended implementation procedures for this criteria, see Chapter VI in the same document.

Table 3. Chesapeake Bay narrative chlorophyll *a* criteria.

Concentrations of chlorophyll *a* in free-floating microscopic aquatic plants (algae) shall not exceed levels that result in ecologically undesirable consequences–such as reduced water clarity, low dissolved oxygen, food supply imbalances, proliferation of species deemed potentially harmful to aquatic life or humans or aesthetically objectionable conditions–or otherwise render tidal waters unsuitable for designated uses.

EVALUATION AREA

The area evaluated for application of the EPA's recommended *Regional Criteria Guidance* is the Chesapeake Bay and its tidal tributaries to the fall line (Figure 2).

FEDERAL LISTED SPECIES WITHIN THE EVALUATION AREA

Appendix C contains a listing of all Federally threatened and endangered species compiled by the U.S. Fish and Wildlife Service and the NOAA National Marine Fisheries Service in the four jurisdictions with tidal influenced Chesapeake Bay waters–Maryland, Virginia, Delaware and the District of Columbia. The species listed include plants, mollusks, fishes, reptiles, birds, insects and mammals. The level of information for each species varies. Only a limited number of threatened or endangered species are aquatic dependent organisms. For this evaluation the following aquatic and aquatic dependent species that still occur in the

Chesapeake Bay and Major Rivers

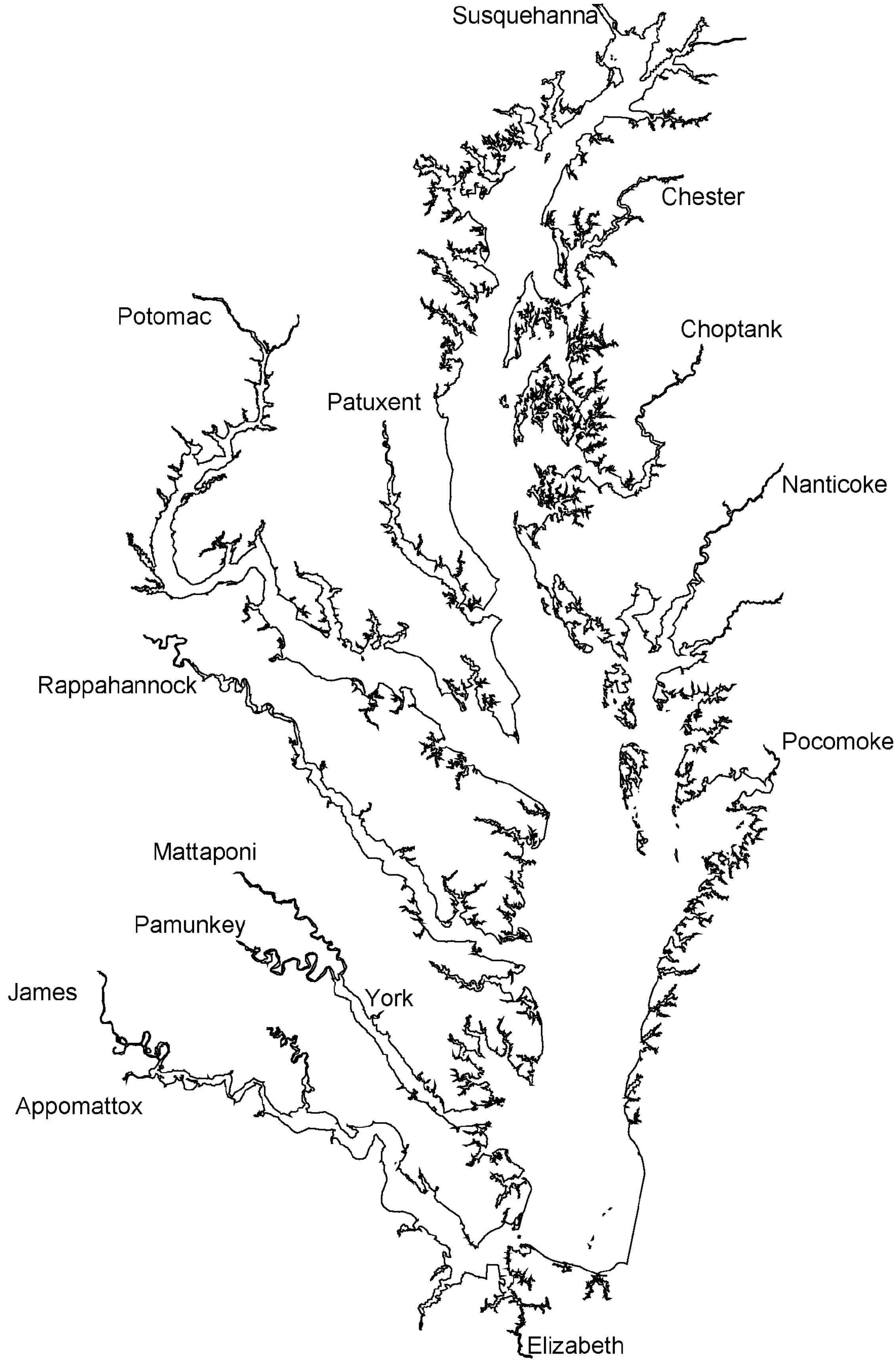

Figure 2. Chesapeake Bay and its tidal tributaries.

region and have been identified through correspondence with the Services were considered:

- Plants–sensitive joint-vetch, swamp pink;
- Mammals–humpback whale, finback whale, blue whale, right whale, sei whale, sperm whale, West Indies manatee;
- Birds–bald eagle, piping plover;
- Fish–shortnose sturgeon, Atlantic sturgeon (state listed);
- Reptiles–loggerhead sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, hawksbill sea turtle and green sea turtle;
- Mollusks–dwarf wedge mussel; and
- Insects–Puritan tiger beetle, northeastern beach tiger beetle.

Plants

The **sensitive joint-vetch** (*Aeschynomene virginica*) is found in Maryland and Virginia (U.S. Fish and Wildlife Service 1992). It is an annual legume native to the eastern United States, growing on the fringe of marshes or shores. The species occurs within the intertidal zone of freshwater tidal river systems where populations are flooded twice daily. Its aquatic dependence is, therefore, intertidal habitat. Its presence in a given marsh may be a factor of displacement by aggressive, non-native plant species, hydrological conditions, salinity tolerances, and/or other parameters. Sensitive joint-vetch seems to favor micro habitats where there is a reduction in competition from other plant species. Bare to sparsely vegetated substrates appear to be a habitat feature of critical importance for establishment and growth of this species. Almost every population of sensitive joint-vetch is susceptible to hydrological changes (e.g., water withdrawal projects), habitat loss and modification (e.g., through bank erosion), or other stressors caused by development.

The **swamp pink** (*Helonias bullata*) is endangered in Maryland and Virginia, and threatened in Delaware. The swamp pink is a distinctive perennial plant with thick stocky rhizomes. It inhabits a variety of freshwater non-tidal wetlands, including spring seepages, swamps, bogs, wet meadows and margins of small streams. The swamp pink does not usually inhabit tidal wetland areas (L. Arroyo, personal communication, 2002). The major threat to the species is loss and degradation of its wetland habitat due to encroaching development, sedimentation, pollution, succession and wetland drainage. Activities that increase sedimentation, pollutant runoff, or cause flooding of habitat should, therefore, be avoided. Human foot traffic or vehicle traffic, as well as beaver dam building constitute other threats to the swamp pink. Site conservation is the primary recovery plan for the swamp pink.

Mammals

Various marine mammals such as the **blue whale** (*Balaenoptera musculus*), **sei whale** (*Balaenoptera borealis*), **sperm whale** (*Physeter catodon*), **right whale** (*Balaena glacialis*), **humpback whale** (*Megaptera novaeangliae*) and **finback whale** (*Balaenoptera physalus*) occur in ocean waters off the coast of Maryland and Virginia (NOAA National Marine Fisheries

Service 1991a, 1991b, 1998b, 1998c). There is some evidence that healthy whales occasionally use bay waters. For example, in 1994, two humpback whales were reported lunge fishing under the Chesapeake Bay Bridge, according to David Scofield, Manager of Ocean Health Programs at the Baltimore Aquarium (D. Scofield, personal communication, 2002). While whales are indeed occasionally seen in the Chesapeake Bay, it is not considered critical habitat for them. Recovery plans include maintaining and enhancing whale habitats, and identifying and reducing death, injury or disturbance to whales caused by humans.

The **West Indies manatee** (*Trichechus manatus latirostris*) is another endangered mammal species that sometimes visits the Chesapeake Bay. Typically manatees live in warm marine/estuarine waters, and eat aquatic grasses, algae, mangrove leaves, and water hyacinths. They usually migrate because of water temperature and salinity. In 1994, a manatee left the area near Jacksonville, Florida on June 15, entered the Chesapeake Bay on July 4, and was spotted in Rhode Island's waters on August 13. While water temperatures in these regions were unusually warm in 1994, David Scofield at the Baltimore Aquarium says that there has been a manatee sighting in the Bay every year since 1994 (D. Scofield, personal communication, 2002). Enough of the sightings have been confirmed that scientists believe this wandering behavior may not be as unusual as once thought. The major causes of mortality are from colliding with watercraft, and getting stuck in flood gates and canal locks.

Birds

The **bald eagle** (*Haliaeetus leucocephalus*) is listed as threatened (U.S. Fish and Wildlife Service 1990). Its aquatic dependence is due to the use of aquatic foraging areas for consumption of aquatic organisms. Chesapeake Bay region bald eagles occupy shoreline habitat of the Chesapeake and Delaware bays and their tributaries. Populations of bald eagles in the Bay region have continued to increase since the recovery plan was written in 1990 (A. Moser, personal communication, 2002). However, the eagle requires large blocks of undisturbed mature forested habitat in proximity to aquatic foraging areas. The principal threat to its continued recovery is habitat loss due to shoreline development and other land use changes. Chesapeake Bay region eagles are also threatened by acute toxicity caused by continued use of certain contaminants, shooting, and accidents. Recovery actions include protection of existing nesting, foraging, and roosting habitat and reduction of mortality from environmental contamination.

The **piping plover** (*Charadrius melodus melodus*) is listed as threatened federally, and also state listed as threatened in Virginia (U.S. Fish and Wildlife Service 1988). Approximately 100 pairs of piping plovers nest on Virginia's Atlantic barrier islands. They are uncommon transients along the southern mainland coast and lower Chesapeake Bay. Plovers are rare transients inland along the Potomac River and rare winter residents in Virginia. Piping plovers arrive at breeding grounds in Virginia around mid-March and lay eggs from mid-April to early July. They breed on sandy, gravel and/or cobbled coastal beaches in areas with little or no vegetation. Piping plovers forage in intertidal zones and wrack lines of ocean beaches, washover areas, mudflats, sandflats, coastal ponds, lagoons and salt marshes, eating marine worms, fly larvae, beetles, crustaceans, mollusks and other invertebrates. Its numbers were drastically reduced in the 20th century because of uncontrolled commercial and recreational hunting and egg collecting in the 1900s, and dune stabilization and beachfront development after World War II. Loss of habitat along with increased recreational use of beaches has caused further population declines. Today the populations are limited by predators (including dogs and cats), flooding of the nest by rain or tidal overwash, development and beach stabilization, and pedestrian and Off Road Vehicle traffic that inadvertently crush eggs or chicks. Continued protection of Virginia's barrier islands for nesting is essential for recovery of this species in Virginia.

Fish

The **Atlantic sturgeon** (*Acipenser oxyrhynchus oxyrhynchus*) is listed as state endangered in Delaware. Federally, the Atlantic sturgeon was placed on the candidate species list in 1988 and again in 1998, though it was never listed (NOAA National Marine Fisheries Service 1998d). It is being considered here due to the moratorium on all Atlantic sturgeon harvests, adopted in 1997 by the Atlantic States Marine Fisheries Commission (Colligan et al. 1998).

The Atlantic sturgeon is an anadromous species, migrating from the ocean to fresh water to spawn. It can live up to 60 years, and reach lengths of up to 14 feet, and weights of over 800 pounds. Sturgeon are typically bottom dwellers, using their snouts to root along the bottom for benthic organisms such as molluscs, insects and crustaceans, which it sucks up with its protrusive mouth. Currently, these sturgeon can be found in 32 rivers from Maine to Georgia, with spawning occurring in at least 14 of these rivers.

The status of the Atlantic sturgeon in the Chesapeake Bay is not certain. There has been no evidence of reproduction in the Maryland portion of the Chesapeake Bay for over 25 years (Speir and O'Connell 1996). Recent evidence suggests limited spawning in the James and York Rivers (NOAA National Marine Fisheries Service 1998d). The initial and most significant threat to the Atlantic sturgeon was commercial fishing, since sturgeons are sought for their eggs (caviar) as well as their flesh. Increased prevalence of hypoxia in the 20th century due to post-World War II agricultural practices and residential development has caused sturgeon habitat degradation in the 1900s (Secor and Niklitschek 2001). All sturgeon fisheries are now closed.

The **shortnose sturgeon** (*Acipenser brevirostrum*) is a Federally listed species. Shortnose sturgeon was listed as endangered on March 11, 1967 (32 FR 4001), and they remained on the endangered species list with the enactment of the Endangered Species Act in 1973 (NOAA National Marine Fisheries Service 1998a, 2002).

The National Oceanic and Atmospheric Administration's National Marine Fisheries Service Shortnose Sturgeon Recovery Plan (Recovery Plan) indicates reports of its occurrence in the Chesapeake system in 1876 (NOAA National Marine Fisheries Service 1998a). The National Marine Fisheries Service Biological Opinion for the Washington Aqueduct Permit (NOAA National Marine Fisheries Service 2002) states that other historical records of shortnose sturgeon in the Chesapeake Bay include: the Potomac River (Smith and Bean 1899), the upper Chesapeake Bay near the mouth of the Susquehanna River in the early 1980s, and the lower Bay near the mouths of the James and Rappahannock rivers in the late 1970s (Dadswell et al. 1984).[1]

The U.S. Fish and Wildlife Service Reward Program for Atlantic Sturgeon began in 1996. Shortnose sturgeon have been incidentally captured via this program. As of July 2002, 50 shortnose sturgeon were captured via the reward program in the Chesapeake Bay and its tributaries–four from the lower Susquehanna River, two in the Bohemia River, six in the Potomac River, two south of the Bay Bridge near Kent Island, one near Howell Point, one just north of Hoopers Island, one in the Elk River, and two in Fishing Bay (Mangold 2003; Spells 2003; Skjeveland et. al. 2000). The remaining 31 shortnose sturgeon were captured in the upper Chesapeake Bay north of Hart-Miller Island. These fish were captured alive in either commercial gillnets, poundnets, fykenets, eel pots, hoop nets, or catfish traps (Mangold 2003; Spells 2003; Skjeveland et. al. 2000).

In many river systems, Shortnose sturgeon appear to spend most of their life in their natal river systems, only occasionally entering higher salinity environments. They are benthic omnivores and continuously feed on benthic and epibenthic invertebrates including molluscs, crustaceans and oligochaete worms (Dadswell 1979).

Shortnose sturgeon depend on free-flowing rivers and seasonal floods to provide suitable spawning habitat. For shortnose sturgeon, spawning grounds have been found to consist mainly of gravel or ruble substrate in regions of fast flow. Flowing water provides oxygen, allows for the dispersal of eggs, and assists in excluding predators. Seasonal floods scour substrates free of sand and silt, which might suffocate eggs (Beamesderfer and Far 1997).

Shortnose sturgeon spawn in upper, freshwater sections of rivers and feed and overwinter in both fresh and saline habitats. In populations that have free access to the total length of a river (absent of dams), spawning areas are located at the farthest accessible upstream reach of the river, often just below the fall line (NOAA National Marine Fisheries Service 1998a). Tributaries of the Chesapeake Bay that appear to have suitable spawning habitat for the Chesapeake Bay shortnose sturgeon include the Potomac, Rappahannock, James, York, Susquehanna, Gunpowder and Patuxent rivers (J. Nichols, personal communication, 2002). Still other scientists believe that very little if any suitable spawning habitat remains for shortnose sturgeon due to past sedimentation in tidal freshwater spawning reaches (Secor, personal communication 2003; J. Musick, personal communication, 2003)

According to the Recovery Plan shortnose sturgeon are affected by habitat degradation or loss (resulting, for example, from dams, bridge construction, channel dredging, and pollutant discharges) and mortality (resulting, for example, from impingement on cooling water intake screens, dredging and incidental capture in other fisheries) as principal threats to the species' survival (NOAA National Marine Fisheries Service 1998a). The recovery goal is identified as delisting shortnose sturgeon populations throughout their range, and the recovery objective is to

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[1] The EPA believes there is a potential that the Dadswell et. al. 1984 referenced observations at the mouths of the James and Rappahannock are incorrect. The authors misidentify the York (as the James) on the map presented in Figure 7 and give two markings, represented by dots in very up-estuary regions (one in York, one in the Mattaponi). No details were given on the number of observations or source.

ensure that a minimum population size is provided such that genetic diversity is maintained and extinction is avoided.

Reptiles

Marine sea turtles include the **loggerhead sea turtle (*Caretta caretta*), Kemp's ridley sea turtle** (*Lepidochelys kempi*), **leatherback sea turtle** (*Dermochelys coriacea*), **hawksbill sea turtle** (*Eretmochelys imbricata*), and **green sea turtle** (*Chelonia mydas*). Sea turtles are migratory; they enter the Chesapeake Bay in late May to early June when water temperatures rise and depart between late September to early November. An estimated 3,000 to as many as 10,000 loggerhead turtles, and perhaps 500 Kemp's ridley sea turtles, use the Chesapeake Bay (J. Musick, personal communication, 2002). Approximately 95 percent of the loggerheads found in the Chesapeake Bay are juveniles, and the area from the mouth of the Bay to the Potomac River serves as an important foraging area for this life stage. Loggerhead sea turtles tend to forage along channel edges in the Bay and tidal rivers while Kemp's ridley sea turtles feed in the water flats. Sea turtles in the Chesapeake Bay (mostly loggerheads and Kemp's ridleys) forage on crustaceans (e.g., crabs) and mollusks. Threats to the turtles include, incidental takes, poaching, pollution and marine habitat degradation. Recovery plans include protection of nesting habitats, eliminating mortality from incidental catch in commercial fishing, and reduction of marine pollution (NOAA National Marine Fisheries Service and U.S. Fish and Wildlife Service 1991a, 1991b, 1992, 1993; U.S. Fish and Wildlife Service and NOAA National Marine Fisheries Service 1992).

Mollusks

The **dwarf wedge-mussel** (*Alasmidonta heterodon*) is endangered in Virginia and was listed as Federally endangered in 1990. The dwarf wedge mussel is an Atlantic Coast freshwater mussel, usually found in sand, firm muddy sand, and gravel bottoms in rivers of varying sizes with slow to moderate current. To survive they need silt-free, stable stream beds and well-oxygenated water that is pollutant free. No host fish are known for this species, but it is thought that in some locations the host fish may be anadromous since these mussel populations have been eliminated in rivers with dams. These mussels are found in Aquia Creek and the South Anna and Nottoway rivers. The dwarf wedge mussel filter feeds on suspended detritus and zooplankton. The dwarf wedge-mussel is salinity intolerant and, therefore, is mainly found in freshwater habitats. They are mainly found in Connecticut and are not found in tidal areas (E. Davis, personal communication, 2002). Habitat degradation is the greatest cause of this species' decline. Industrial pollution, intensive recreational development, urban and agricultural development, and siltation have adverse effects on this species.

Insects

The **Puritan tiger beetle** (*Cicindela uritana*) was listed as Federally threatened in 1990, and is endangered in Maryland (U.S. Fish and Wildlife Service 1993). It is found in Kent, Cecil, and Calvert counties. It occurs on open sand flats, dunes, water edges, beaches, woodland paths and sparse grassy areas. Populations have declined due to habitat alterations associated with human population growth, as well as inundation and disturbance of its shoreline habitat from dam construction, riverbank stabilization, and other human activities. The beetle larvae, in particular, are sensitive to natural and human-induced changes to beaches and bluffs, as well as human traffic and water-borne pollution.

The **northeastern beach tiger beetle** (*Cicindela dorsalis dorsalis*) is listed as threatened in Maryland, and proposed threatened in Virginia (U.S. Fish and Wildlife Service 1994). It occurs in over 50 sites within the Chesapeake Bay region. Northeastern beach tiger beetles are rare beach-dwellers that occur on open sand flats, dunes, water edges, beaches, woodland paths, and sparse grassy areas. The beetle is most vulnerable to disturbance during the larval stage, which lasts two years. Larvae live in vertical burrows, generally in the beach intertidal zone where they are particularly sensitive to destruction by high levels of pedestrian traffic, Off Road Vehicles, and other changes due to coastal development and beach stabilization structures. It is tolerant to aquatic changes and is more dependent on beach conditions for survival (B. Knisley, personal communication, 2002)

STATUS OF LISTED SPECIES

For the reasons stated below, the EPA has determined through consultation with the U.S. Fish and Wildlife Service and the NOAA National Marine Fisheries Service, that the issuance of the *Regional Criteria Guidance* is not likely to adversely affect the listed species below (K. Mayne, written correspondence, April 22, 2003, 2003; M. Ratnaswamy, written correspondence, 2003; M. Colligan, written correspondence, 2003). Therefore no further consultation is necessary with respect to these species:

- The **swamp pink** (*Helonias bullata*) does not usually inhabit tidal wetland areas. The Chesapeake Bay and its tidal tributaries (evaluation area) are not considered important habitat for this species.
- **Blue whale** (*Balaenoptera musculus*), **sei whale** (*Balaenoptera borealis*), **sperm whale** (*Physeter catodon*), **right whale** (*Balaena glacialis*), **humpback whale** (*Megaptera novaeangliae*), **finback whale** (*Balaenoptera physalus*), and **West Indies manatee** (*Trichechus manatus latirostris*) have been known to occasionally wander into the Chesapeake Bay waters, however, it is not considered important habitat for them. The major threat to these species is direct human physical contact.
- The **dwarf wedge-mussel** (*Alasmidonta heterodon*) is not found in the evaluation area.
- The **northeastern beach tiger beetle** (*Cicindela dorsalis*) is dependant on beach conditions for survival.
- The **Puritan tiger beetle** (*Cicindela uritana*) is mainly threatened by human activities such as population growth, disturbance of its shoreline habitat and construction of dams.
- **Loggerhead sea turtle (*Caretta caretta*), Kemp's ridley sea turtle** (*Lepidochelys kempi*), **leatherback sea turtle** (*Dermochelys coriacea*), **hawksbill sea turtle** (*Eretmochelys imbricata*), **green sea turtle** (*Chelonia mydas*) mainly use the Bay for foraging during juvenile life stages. Sea turtle prey species will benefit from the *Regional Criteria Guidance*.
- The **bald eagle** (*Haliaeetus leucocephalus*) is a predator, and scavenger, exploiting a variety of food sources such as birds, mammals, fish (consisting primarily of menhaden, large gizzard shad, white perch and catfish) and waterfowl depending upon food abundance. The *Regional Criteria Guidance* would encourage improved conditions for these species of fish, particularly spawning habitat.
- The **piping plover** (*Charadrius melodus melodus*) are mainly found on the Atlantic coast and are mainly threaten due to the depletion in prime nesting habitat areas.

- The **sensitive joint-vetch** (*Aeschynomene virginica*) are mainly susceptible to water withdrawal projects or habitat loss, modification, or degradation caused by development.

Therefore, the only endangered or threatened species under the NOAA Fisheries jurisdiction in the evaluation area that will potentially be affected is the endangered **shortnose sturgeon** (*Acipenser brevirostrum*) (K. Mayne, written correspondence, 2003; M. Ratnaswamy, written correspondence, 2003; M. Colligan, written correspondence, 2003). No critical habitat has been designated for the shortnose sturgeon (NOAA National Marine Fisheries Service 1998a).

MANNER IN WHICH *REGIONAL CRITERIA GUIDANCE* MAY AFFECT THE SHORTNOSE STURGEON

Water Clarity

The recommended Chesapeake Bay water clarity criteria, if adopted by each state and approved by the EPA would establish the minimum level of light penetration required to support the survival and continued propagation of underwater bay grasses in both lower and higher salinity communities (U.S. Environmental Protection Agency 2003a). The *Regional Criteria Guidance* provides documentation which supports that attaining water clarity at the proposed levels will improve underwater bay grass survival, growth and propagation, thus improving habitat to fully support a diverse shallow water habitat. Based on the recommended criteria and the evaluations for each listed species described above, which includes the habitat and spawning areas of the species and threat to species recovery, the EPA has determined that the recommended water clarity criteria will not likely adversely effect the listed species evaluated in this document. Furthermore, the EPA has determined that the proposed water clarity criteria will beneficially affect preferred habitat, spawning areas and food sources that will add substantially in the recovery of the shortnose sturgeon.

Chlorophyll *a*

The recommended Chesapeake Bay narrative chlorophyll *a* criteria and technical information supporting states' quantitative interpretation of the narrative criteria provides concentrations characteristic of desired ecological trophic conditions and protective against water quality and ecological impairments (U.S. Environmental Protection Agency 2003a). These recommended concentrations are given to prevent reduced water clarity, low dissolved oxygen, food supply imbalances, proliferation of species deemed potentially harmful to aquatic life or humans, or aesthetically objectionable conditions. The *Regional Criteria Guidance* provides documentation which indicate that water clarity and dissolved oxygen improve when excess phytoplankton measured as chlorophyll *a* are significantly reduced, thus improving water quality and critical aquatic habitat in the waters of the Chesapeake Bay and its tidal tributaries. The EPA has determined that the recommended chlorophyll *a* criteria will not likely adversely affect the listed species evaluated in this document. Furthermore, the EPA has determined that the recommended chlorophyll *a* criteria will beneficially affect preferred habitat, spawning areas and food sources that the listed species depends on.

Dissolved Oxygen

A set of dissolved oxygen criteria have been derived to protect Chesapeake Bay estuarine species based on the EPA's conclusions and scientific research on the different Bay habitats (see chapters III and VI in Appendix A; U.S. Environmental Protection Agency 2003a). Oxygen dynamics and natural low- to no-oxygen conditions were also fully considered in the development of the refined tidal water designated uses (see Appendix B; U.S. Environmental Protection Agency 2003b) which factor in natural conditions leading to low dissolved oxygen concentrations.

Chesapeake Bay Oxygen Dynamics

Taking into account the natural processes that control oxygen dynamics is critical to identifying the different Bay aquatic life habitats and establishing criteria reflective of natural conditions and protective of each habitat. The Chesapeake Bay tends to have naturally reduced dissolved oxygen conditions in its deeper waters because of its physical morphology and estuarine circulation. As in other estuarine systems (e.g., Boynton et al. 1982; Nixon 1988; Caddy 1993; Cloern 2001), the Chesapeake's highly productive waters combined with sustained stratification, long residence times, low tidal energy and tendency to retain and recycle nutrients set the stage for lower dissolved oxygen conditions. The mesohaline mainstem Chesapeake Bay and lower reaches of the major tidal rivers have a stratified water column, which essentially prevents waters near the bottom from mixing with more oxygenated surface waters. Recycling of nutrients and water-column stratification leads to severe reductions in dissolved oxygen concentrations during the warmer months of the year in deeper waters within and below the pycnocline.

This reduction in dissolved oxygen generally results from a host of additional biological and physical factors (e.g., Kemp and Boynton 1980; Kemp et al. 1992; Sanford et al. 1990; Boynton and Kemp 2000). The annual spring freshet delivers large volumes of fresh water to the Chesapeake Bay. The contribution of significant quantities of nutrients in the spring river flows, combined with increasing temperatures and light, produces a large increase in phytoplankton biomass. Phytoplankton not consumed by suspension feeders (such as zooplankton, oysters and menhaden) sink to the subpycnocline waters, where they are broken down by bacteria over a period of days to weeks (e.g., Malone et al. 1986; Tuttle et al. 1987; Malone et al. 1988). This loss of oxygen due to bacterial metabolism is exacerbated due to the onset of increased stratification, which restricts mixing with surface waters.

The Chesapeake Bay's nearshore shallow waters periodically experience episodes of low to no dissolved oxygen, in part because bottom water has been forced into the shallows by a combination of internal lateral tides and sustained winds (Carter et al. 1978; Tyler 1984; Seliger et al. 1985; Malone et al. 1986; Breitburg 1990; Sanford et al. 1990). Low dissolved oxygen conditions in shallow waters of the tidal tributaries are more often the result of local production/respiration than the incursion of bottom waters. Climatic conditions such as calm winds and several continuous cloudy days in a row can contribute to oxygen depletion in these shallow water habitats. These habitats can be exposed to episodes of extreme and rapid fluctuations in dissolved oxygen concentrations (Sanford et al. 1990). In depths as shallow as 4 meters, dissolved oxygen concentrations may decline to 0.5 mg liter^{-1} for up to 10 hours (Breitburg 1990).

Diel cycles of low dissolved oxygen conditions often occur in non-stratified shallow waters where water-column respiration at night temporarily reduces dissolved oxygen levels (D'Avanzo and Kremer 1994). In nearshore waters of the mesohaline mainstem Chesapeake Bay, near-bottom dissolved oxygen concentrations are characterized by large diel fluctuations and daily minima during the late night and early morning hours of July and August (Breitburg 1990).

The timing and extent of reduced dissolved oxygen conditions in the Chesapeake Bay vary from year to year, largely driven by local weather patterns, the timing and magnitude of freshwater river flow and concurrent delivery of nutrients and sediments into tidal waters, and the corresponding springtime phytoplankton bloom (Officer et al. 1984; Seliger et al. 1985; Boynton and Kemp 2000; Hagy 2002). In the Chesapeake Bay's mesohaline mainstem, these conditions generally occur from June through September but have been observed to occur as early as May and may persist through early October, until the water column is fully mixed in the fall. The deeper waters of several major Chesapeake Bay tidal tributaries can also exhibit hypoxic and anoxic conditions (Hagy 2002).

Derivation of Chesapeake Bay Dissolved Oxygen Criteria

The derivation of these criteria followed the methodologies outlined in the EPA's *Guidelines for Deriving Numerical National Water Quality for the Protection of Aquatic Organisms and their Uses* (U.S. Environmental Protection Agency 1985), the risk-based approach used in developing the *Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras* (U.S. Environmental Protection Agency 2000) and the *Biological Evaluation on the CWA 304(a) Aquatic Life Criteria as part of the National Consultations, Methods Manual* (*National Consultation*) (U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service and National Marine Fishers Service, in draft). The resulting criteria specifically factored in the physiological needs and habitats of the Bay's living resources and were structured to protect five distinct tidal water designated uses (U.S. Environmental Protection Agency 2003a, 2003b).

Criteria for protecting the migratory fish spawning and nursery, shallow-water bay grass and open-water fish and shellfish designated uses were set at levels to protect the growth, recruitment and survival. Criteria applicable to deep-water seasonal fish and shellfish designated uses were set at levels to protect shellfish and juvenile and adult fish, and to foster the recruitment success of the bay anchovy. Criteria for deep-channel seasonal refuge designated uses were set to protect the survival of bottom sediment-dwelling worms and clams. These summer season deep-water and deep-channel designated uses take into account the limited aquatic life uses due to the natural historic presence of low oxygen in these habitats and the likelihood that such conditions may persist although significantly improved over present conditions (U.S. Environmental Protection Agency 2003b).

Shortnose Sturgeon Dissolved Oxygen Sensitivity

Sturgeon in the Chesapeake Bay and elsewhere are more sensitive to low dissolved oxygen conditions than most other fish. In comparison with other fishes, sturgeon have a limited behavioral and physiological capacity to respond to hypoxia (multiple references reviewed and cited by Secor and Niklitschek 2001, 2003). Sturgeon basal metabolism, growth, consumption and survival are all very sensitive to changes in oxygen levels, which may indicate their relatively poor ability to oxyregulate. In summer, temperatures greater than 20°C amplify the effect of hypoxia on sturgeon and other fishes due to a temperature-oxygen 'habitat squeeze' (Coutant 1987). Deep waters with temperatures that sturgeon prefer tend to have dissolved oxygen concentrations naturally below the minimum that they require. Sturgeon are therefore either forced to occupy unsuitable habitats or have a reduction in habitat.

Several studies have directly addressed the lethal effects of hypoxia on sturgeon species important to the Chesapeake Bay. Jenkins et al. (1993) examined the effects of different salinities and dissolved oxygen levels on juveniles of the shortnose sturgeon *(Acipenser brevirostrum)*. The dissolved oxygen tests were all conducted at a mean temperature of 22.5°C. The authors state:

> Due to various constraints including limitations of facilities and test animals, strictly controlled and standardized methods could not be followed in all tests. The findings reported should be considered as preliminary until such time as more rigorous testing can be accomplished.

In addition, the authors report nominal[2] oxygen levels rather than those specific D.O. levels experienced during each replicate experiment. All experiments were conducted in freshwater. Still, there was strong evidence presented that younger fish were differentially susceptible to low oxygen levels in comparison to older juveniles. Fish older than 77 days experienced minimal mortality at nominal levels ≥2.5 mg/L, but at 2.0 mg liter^{-1} experienced 24 to 38 percent mortality. Younger fish experienced 18 to 38 percent mortality in the 3.0 mg liter^{-1} and >80% mortality in the 2.5 mg liter^{-1} treatment. Mortality of juveniles ≤77 days at treatment levels ≥3.5 mg liter^{-1} was not significantly different than control levels. Because only nominal levels were reported, the EPA could derive LC_{50} values based upon responses reported by Jenkins et al. (1993).

Dissolved Oxygen Criteria Protective of Shortnose Sturgeon

More rigorous tests with shortnose sturgeon were recently performed using young-of-the-year fish 77 to 134 days old (Campbell and Goodman 2003). Campbell and Goodman (2003) present four 24-hr LC_{50} values for shortnose sturgeon (*Acipenser brevirostrum*). Three of these are from tests with non-stressful temperatures (22-26°C) for this species. The fourth test was conducted at 29°C and was considered to be a stressful temperature by the authors (L. Goodman, personal communication, 2003). Fish from this fourth test also were exposed to temperatures as high as 31°C during the acclimation period immediately preceding their exposure to hypoxia. Since the data from the fourth test also include an effect due to temperature stress they should be considered separately from that of the other three tests.

The most latest draft (December 2002) of the *National Consultation* on threatened and

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[2] The authors report that dissolved oxygen levels were monitored every 30 minute throughout the 6 hour tests, and state that each parameter remained at 'satisfactory levels'. The dissolved oxygen values reported are 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0 and 7.5 mg liter^{-1}. Since up to five replicates were used with as many as 12 measurements, it seems very unlikely that these exact dissolved oxygen concentration values were maintained consistently throughout all the tests.

endangered species (being negotiated between the U.S. EPA, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service) states:

> Where acute toxicity data are available for the species of interest, only these data will be used for designating the LC_{50} for this species. If these data include more than one test, the geometric mean of the LC_{50}s of these tests will be used in risk calculations. If only one toxicity test has been conducted, the lower 95% confidence interval of the LC_{50} from this test will be used.

Following this guidance the final LC_{50} for shortnose sturgeon under ambient conditions of non-stressful temperatures would be the geometric mean of 2.2, 2.2 and 2.6 mg liter^{-1} —2.33 mg liter^{-1}. Under stressful temperatures the LC_{50} value that should be used would be 3.1 mg liter^{-1} (this is the LC_{50} of the 29°C test, since the 3.1 mg liter^{-1} treatment resulted in exactly 50 percent mortality there was no 95 percent confidence interval) (Campbell and Goodman 2003).

Long-term exposures (10 days) of Atlantic sturgeon, *Acipenser oxyrinchus,* young-of-the-year (150 to 200 days old) to 2.8 to 3.3 mg liter^{-1} at 26°C resulted in complete mortality over a 10-day period in three of four replicates (Secor and Gunderson 1998). The fourth replicate experienced 50 percent mortality. At 19°C and 2.3 to 3.2 mg liter^{-1}, only 12 to 25 percent mortality was recorded. There was insufficient data to calculate an LC_{50} for 19°C (was less than 2.70 mg liter-^{1}, but could not determine how much less). However, based on survival data present in Secor and Gunderson (1998), a 96-hr LC_{50} of 2.89 mg liter^{-1} [3] was estimated for Atlantic sturgeon at 26°C. This value is very similar to the 'high temperature' value of 3.1 mg liter^{-1} calculated for shortnose sturgeon by Campbell and Goodman (2003). Data from Niklitschek and Secor (2001) show that shortnose sturgeon are more tolerant of higher temperatures than Atlantic sturgeon, which could explain why 26°C is not a stressful temperature for shortnose sturgeon (Campbell and Goodman 2003), but is for Atlantic sturgeon (Secor and Gunderson 1998). Alternately, the temperature difference between the two species could be because the shortnose sturgeon were from Savannah River progeny and were held at higher temperatures than the Atlantic sturgeon which came from Hudson River progeny.

Using the above data, the EPA calculated acute criteria for the protection of sturgeon survival in the Chesapeake Bay under both non-stressful and stressful temperatures for habitats appropriate for sturgeon use. The only LC_{50} value available for non-stressful temperatures that meets the requirements for criteria derivation based on EPA's 1985 guidelines (U.S. Environmental Protection Agency 1985) is the 24-hr 2.33 mg liter^{-1} calculated above from Campbell and Goodman (2003). To be consistent with EPA guidelines, this value was used with the original EPA Virginian Province saltwater dissolved oxygen criteria acute data set to recalculate the Final Acute Value (FAV). The new FAV, 2.12 mg liter^{-1}, is more protective than the 1.64 mg liter^{-1} from the Virginian Province document, but not as protective as the 2.33 mg

[3]Based on daily dissolved oxygen data provided by the lead author, Dr.David Secor, University of Maryland Center for Environmental Studies, Chesapeake Biological Laboratory, Solomons, Maryland.

liter^{-1} value. Therefore, we default to the 2.33 mg liter^{-1} value, multiplying it by 1.38[4] to arrive at a new CMC, 3.2 mg liter^{-1} (rounded to two significant figures). This value is expected to be protective of sturgeon survival at non-stressful temperatures. Campbell and Goodman (2003) indicate that most of the mortality for shortnose sturgeon occurs within the first 2 to 4 hours of a test. Therefore, using this value as an instantaneous value should protect sturgeon under most conditions.

A higher dissolved oxygen criterion would be needed in areas and times of the year where sturgeon are to be protected and temperatures are likely to be considered stressful (e.g., 29°C and above for shortnose sturgeon). The simplest approach is to use the LC_{50} value of 3.1 mg liter^{-1} from the fourth test of Campbell and Goodman (2003). Multiplying this by 1.38 results in a high temperature CMC for shortnose sturgeon of 4.3 mg liter^{-1}.

To determine a criterion value that would also protect sturgeon from nonlethal effects in the habitats for sturgeon use, bioenergetic and behavioral responses were considered which had been derived from laboratory studies conducted on juvenile Atlantic and shortnose sturgeon (Niklitschek 2001; Secor and Niklitschek 2001). Growth was substantially reduced at 40 percent oxygen saturation compared to normal oxygen saturation conditions (greater than or equal to 70 percent saturation) for both species at temperatures of 20° C and 27° C. Metabolic and feeding rates declined at oxygen levels below 60 percent oxygen saturation at 20° C and 27° C. In behavior studies, juveniles of both sturgeon species actively selected 70 percent or 100 percent oxygen saturation levels over 40 percent oxygen saturation levels. Based on these findings, a 60 percent saturation level was deemed protective for sturgeon. This corresponds to 5 mg liter^{-1} at 25° C. Therefore, a 5 mg liter^{-1} Chesapeake Bay dissolved oxygen criterion protecting against adverse growth effects would protect sturgeon growth as well.

Tidal Water Designated Use Habitats

The migratory spawning and nursery and open-water designated uses are by their very design and definitions protective of shortnose sturgeon. The deep-water and deep-channel designated uses are seasonally applied to open-water habitats where and when water column stratification prevents the free exchange of oxygenated waters with the surface mixed layer. These two designated uses were not established to be protective of oxygen sensitive species like sturgeon during the summer months in recognition of natural processes that make this habitat unsuitable for such species during the June through September time frame as discussed below.

Chesapeake Bay Low Oxygen: Historical and Recent Past

Dissolved oxygen levels vary naturally in lakes, estuaries and oceans over varying temporal and spatial scales due to many biological, chemical and physical processes. In estuaries such as the Chesapeake Bay, freshwater inflow that influences water-column stratification; nutrient input and cycling; physical processes such as density-driven circulation;

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[4]This value is the geometric mean of the LC_5/LC_{50} ratios from the Virginian Province document. The ratio for the shortnose sturgeon tests from Campbell and Goodman (2003) was 1.30 (based on an analysis of raw data provided by the co-author Larry Goodman, U.S. Environmental Protection Agency, Office of Research and Development, Gulf Ecology Division, Gulf Breeze, Florida). To be consistent with the Virginian Province document, the EPA applied the 1.38 ratio.

and tides, winds, water temperature and bacterial activity are among the most important factors. These processes can lead to large natural seasonal and interannual variability in oxygen levels in many parts of the Chesapeake Bay and its tidal tributaries.

Superimposed on this natural dissolved oxygen variability is a progressive increase in the intensity and frequency of hypoxia and anoxia over the past 100 to 150 years, most notably since the 1960s. This human-induced eutrophication is evident both from instrumental data and geochemical and faunal/floral 'proxies' of dissolved oxygen conditions obtained from the sedimentary record.

The instrumental record, while incomplete prior to the inception of the multi-agency Chesapeake Bay Monitoring Program in 1984, suggests that as early as the 1900s to 1930s (Sale and Skinner 1917; Newcombe and Horne 1938; Newcombe et al. 1939) and especially since the 1960s (Taft et al. 1980; Hagy 2002), summer oxygen depletion has been recorded in the Chesapeake Bay. Officer et al. (1984), Malone (1992), Harding and Perry (1997) and Hagy (2002) provide useful discussions of the instrumental record of dissolved oxygen and related parameters such as chlorophyll *a* across this multi-decadal data record.

At issue is whether, and to what degree, dissolved oxygen reductions are a naturally occurring phenomenon in the Chesapeake Bay thereby creating habitats at certain times of year that are unsuitable for species including the sturgeon. Long sediment core (17 to greater than 21 meters in length) records indicate that the Chesapeake Bay formed about 7,500 years ago (Cronin et al. 2000, Colman et al. 2002) when the rising sea level after the final stage of Pleistocene deglaciation flooded the Susquehanna channel. The modern estuarine circulation and salinity regime probably began in the mid- to late Holocene epoch, about 4,000-5,000 years ago (in the regional climate of the early Holocene, the Chesapeake Bay's salinity differed from that of the late Holocene). This is based on the appearance of 'pre-colonial' benthic foraminiferal, ostracode and dinoflagellate assemblages. It is against this mid- to late Holocene baseline that we can view the post-European settlement and modern dissolved oxygen regime of the Chesapeake Bay.

During the past decade, studies of the Chesapeake Bay's late Holocene dissolved oxygen record have been carried out using several proxies of past dissolved oxygen conditions, which are preserved in sediment cores that have been dated using the most advanced geochronological methods. These studies, using various indicators of past dissolved oxygen conditions, are reviewed in Cronin and Vann (2003) and provide information that puts the monitoring record of the modern Chesapeake Bay into a long-term perspective and permits an evaluation of natural variability in the context of restoration targets. The following types of measurements of oxygen-sensitive chemical and biological indicators have been used: nitrogen isotopes (Bratton et al., 2003); biogenic silica and diatom communities (Cooper and Brush 1991; Cooper 1995; Colman and Bratton 2003); molybdenum and other metals (Adelson et al. 2000; Zheng et al., 2003); lipid biomarkers; acid volatile sulfur (AVS)/chromium reducible sulfur (CRS) ratios; total nitrogen and total organic carbon (Zimmerman and Canuel 2000); elemental analyses (Cornwell et al. 1996) and paleo-ecological reconstructions based on dinoflagellate cysts (Willard et al. 2003); and benthic foraminiferal assemblages (Karlsen et al. 2000). Although space precludes a comprehensive review of these studies, and the time period studied and level of quantification vary, several major themes emerge, which we summarize here.

First, the 20th century sedimentary record confirms the limited monitoring record of dissolved oxygen, documenting that there has been a progressive decrease in dissolved oxygen levels, including the periods of extensive anoxia in the deep-channel region of the Chesapeake Bay that have been prominent during the last 40 years. Most studies provide strong evidence that there was a greater frequency or duration of seasonal anoxia beginning in the late 1930s and 1940s and again around 1970, reaching unprecedented frequencies and/or duration in the past few decades in the mesohaline Chesapeake Bay and the lower reaches of several tidal tributaries. Clear evidence of these low dissolved oxygen conditions has been found in all geochemical and paleo-ecological indicators studied principally through their great impact on benthic and phytoplankton (both diatom and dinoflagellate) communities.

Second, extensive late 18th and 19th century land clearance also led to oxygen reduction and hypoxia, which exceeded levels characteristic of the previous 2,000 years. Best estimates for deep-channel mid-bay seasonal oxygen minima from 1750 to around 1950 are 0.3 to 1.4-2.8 mg $liter^{-1}$ and are based on a shift to dinoflagellate cyst assemblages of species tolerant of low dissolved oxygen conditions. This shift is characterized by a four- to fivefold increase in the flux of biogenic silica, a greater than twofold (5-10 $milliliter^{-1}$) increase in nitrogen isotope ratios (^{15}N) and periods of common (though not dominant) *Ammonia parkinsoniana*, a facultative anaerobic foraminifer. These patterns are likely due to increased sediment influx and nitrogen and phosphorous runoff due to extensive land clearance and agriculture.

Third, before the 17th century, dissolved oxygen proxy data suggest that dissolved oxygen levels in the deep channel of the Chesapeake Bay varied over decadal and interannual time scales. Although it is difficult to quantify the extremes, dissolved oxygen probably fell to 3-6 mg $liter^{-1}$, but rarely if ever fell below 1.4-2.8 mg $liter^{-1}$. These paleo-dissolved oxygen reconstructions are consistent with the Chesapeake Bay's natural tendency to experience seasonal oxygen reductions due to its bathymetry, freshwater-driven salinity stratification, high primary productivity and organic matter, and nutrient regeneration (Boicourt 1992; Malone 1992; Boynton et al. 1995).

In summary, the main channel of the Chesapeake Bay most likely experienced reductions in dissolved oxygen before large-scale post-colonial land clearance took place, due to natural factors such as climate-driven variability in freshwater inflow. However, this progressive decline in summer oxygen minima, beginning in the 18th century and accelerating during the second half of the 20th century, is superimposed on past and present interannual and decadal patterns of dissolved oxygen variability. Human activity during the post-colonial period has caused the trend towards hypoxia and most recently (especially post-1960s) anoxia in the main channel of the Chesapeake Bay and some of its larger tributaries. The impact of these patterns has been observed in large-scale changes in benthos and phytoplankton communities, which are manifestations of habitat loss and degradation.

Historical and Potential Sturgeon Tidal Habitats

Atlantic and shortnose sturgeon probably most recently colonized the Chesapeake Bay 5,000-8,000 years ago after the last glaciation, when climate and the watershed's hydraulic regime became more stable (Custer 1986; Miller 2001). The Chesapeake Bay during this period already exhibited the two-layer circulation pattern. Thus, we should expect that deep-channel habitats during periods of strong stratification were hypoxic during the past 5,000 years, albeit not at the same spatial extent or severity that has occurred over the past 50 years (Officer et al. 1985; Cooper and Brush 1991). Atlantic sturgeon in other estuarine and coastal systems will use habitats greater than 15 meters in depth (see below), but these other systems do not exhibit the same characteristics of estuarine circulation, watershed areal extent and bathymetry that contributes to natural deep-water and deep-channel hypoxia in the mesohaline Chesapeake Bay.

<u>Deep-Channel Habitats</u>

The geochemical, paleoecological, and instrumental record of the 20th century indicates that deep-channel regions have not served as potential habitats for sturgeon because seasonal (summer) anoxia and hypoxia have occurred most years, reaching and sustaining levels below those required by sturgeon. Hypoxia, and probably periodic, spatially-limited anoxia, occurred in the Chesapeake Bay prior to the large-scale application of fertilizer, but since the 1960s oxygen depletion has become much more severe, prohibiting sturgeon use of this habitat during summer months (Hagy 2002).

Analysis of recent U.S. Fish and Wildlife Service sturgeon capture location data showed absence of sturgeon occurrences in deep-channel habitats during summer months (June 1 through September 30), but substantial numbers of occurrences in these same habitats during other seasons (U.S. Environmental Protection Agency 2003b). Based upon the recent relevant history of the Chesapeake Bay ecosystem, the deep-channel regions in summer are not considered sturgeon habitats.

<u>Deep-Water Habitats</u>

Deeper water-column regions may continue to support foraging, temperature refuges, and migration corridors for sturgeons during times in the absence of strong water-column stratification which naturally result in dissolved oxygen concentrations well below saturation due to restrictions in mixing with the well-oxygenated surface mixed layer. In other estuarine and coastal systems where strong water-column stratification does not occur to the degree observed in the Chesapeake Bay and its tidal tributaries, both sturgeon species are known to use deep-water habitats in summer months as thermal refuges (see section titled "Life History of Shortnose Sturgeon").

The water column in the mesohaline Chesapeake Bay mainstem and the mesohaline lower tidal reaches of several major tributaries (Chester, Patapsco, Patuxtent, Potomac and Rappahannock river) stratifies to the point where within pycnocline (deep-water) and below pycnocline (deep-channel) waters are effectively prevented from receiving oxygenated waters from the overlying surface mixed layer (open-water) during the summer months. These mesohaline (>5-18 ppt) waters are also far enough removed from the free flowing rivers and the ocean to prevent re-oxygenation through the inflow of oxygenated bottom waters. During the period 1990-1999, very little summer time deep-water habitat was predicted to support sturgeon production based upon a bioenergetics model, due principally to pervasive hypoxia (Niklitschek and Secor, in review). Further, sturgeons are able to behaviorally respond to favorable gradients in dissolved oxygen (Secor and Niklitschek 2001) and, thus, will avoid the naturally lower dissolved oxygen waters.

Recent fisheries dependent and independent data synthesized by the U.S. Fish and Wildlife Service (Mangold 2003; Spells 2003; Skjeveland et. al. 2000) did not show substantial overlap during summer months between deep-water regions and shortnose sturgeon occurrences. The EPA recognizes this data base contains fisheries dependent data collected through incidential catch by gear (i.e., pound nets) deployed generally in waters less than 7 meters in depth.

Figure 3 illustrates shortnose sturgeon capture locations during the June 1 through September 30 timeframe with Figure 4 illustrating the locations of all 50 shortnose sturgeon captures in Chesapeake Bay throughout the year since 1994 through March 2003. Outside of the June 1 through September 30 time frame, shortnose sturgeon captures were reported across all tidal water habitats, including habitats seasonally designated as deep water or deep channel, but protected as open-water habitats from the beginning of October through the end of May. Through an in-depth analysis of the 400 station, 1400 individual sturgeon (both Atlantic and shortnose sturgeon) U.S. Fish and Wildlife Service captures database, no recorded shortnose sturgeon captures overlapped with the seasonally defined deep-water habitat.

Based upon this analysis, it does not appear likely that habitat found within pycnocline deep water would comprise 'potential'habitats for sturgeons during periods of strong water column stratification limiting exchange with overlying, more oxygenated waters. In the absence of strong water column stratification, these deeper depth water column habitats are considered open water habitat and comprise 'potential' habitats for sturgeons.

Salinity Tolerances

During their first year of life, shortnose sturgeon tend to occur in fresh water (Dovel et al. 1992; Haley 1999) but can tolerate salinities up to 15 ppt (Jenkins et al. 1993; Niklitschek 2001). Extensive observational and experimental evidence points toward shortnose sturgeon concentrating in habitats with less than 5 ppt for all life history stages during summer months (Dadwell 1984; Dovel et al. 1992; Geogehan et al. 1984; Brundage and Meadows 1982; Collins and Smith 1996; Bain 1997; Haley 1999). Laboratory experiments also showed that young-of-the-year Atlantic sturgeon are more likely to survive in salinities greater than or equal to 15 ppt (Niklitschek 2001). Based on distributional evidence, older juvenile and adult shortnose sturgeon are limited to oligohaline and low mesohaline regions of estuaries (<15 ppt), while by their second year of life, Atlantic sturgeon fully tolerate salinities ranging from 0 to 35 ppt (Dovel and Berggen 1983; Dovel et al. 1992; Kieffer and Kynard 1993; Colligan et al. 1998).

Jenkins et al. (1993) exposed shortnose sturgeon young-of-the-year (age 22-330 days) to acute transitions in salinity for periods of 18-96 hr. Larvae (22 d ays old) showed >50 percent mortality at 9 ppt exposure for 48 hours. Juveniles (63 days [48 hr] and 76 days old[96 hr])

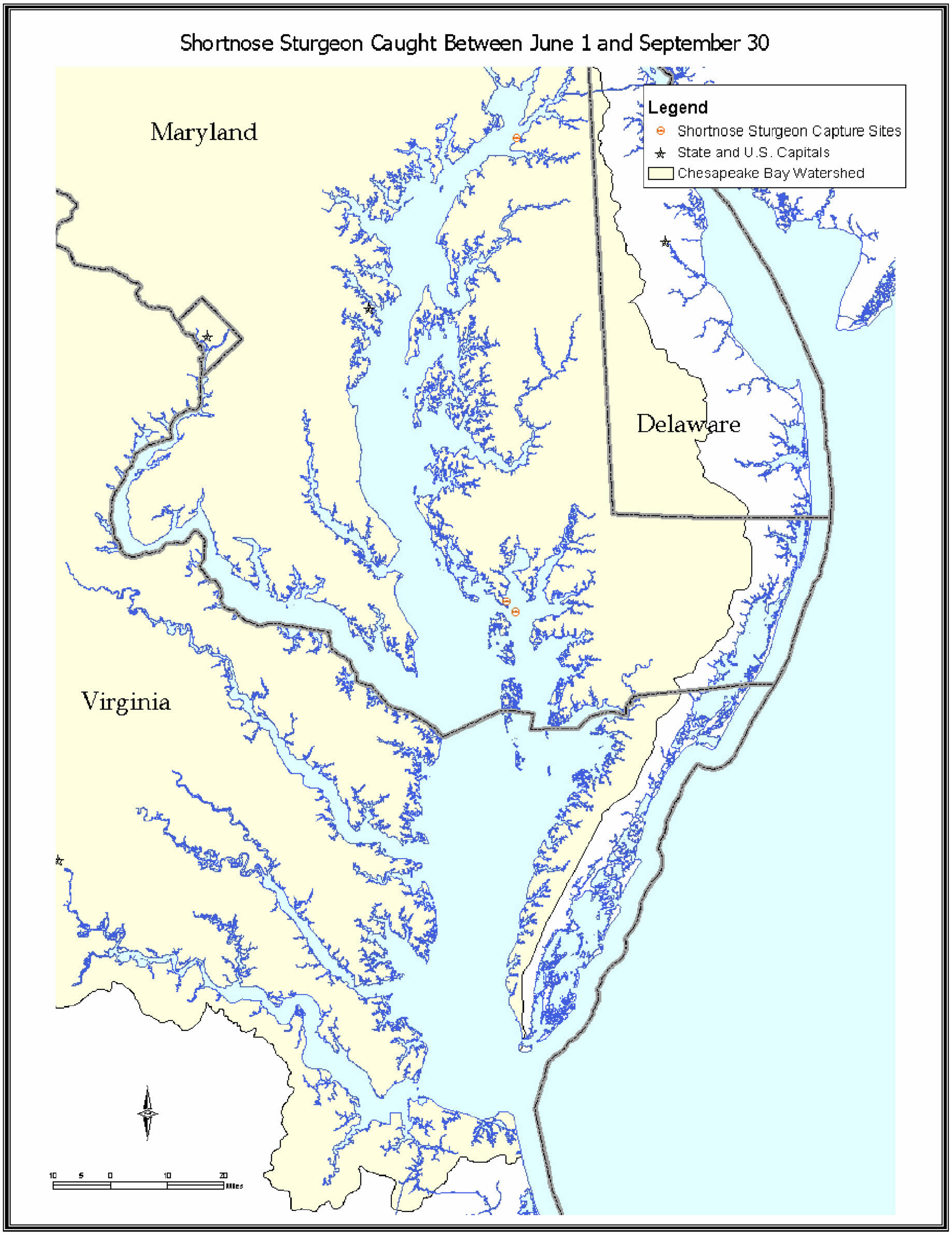

Figure 3. Map of all U. S. Fish and Wildlife Service sturgeon capture location stations where shortnose sturgeon were caught from June 1-September 30, 1999-March 2003.

Sources: Mangold 2003, Spells 2003, Skeveland et al. 2000.

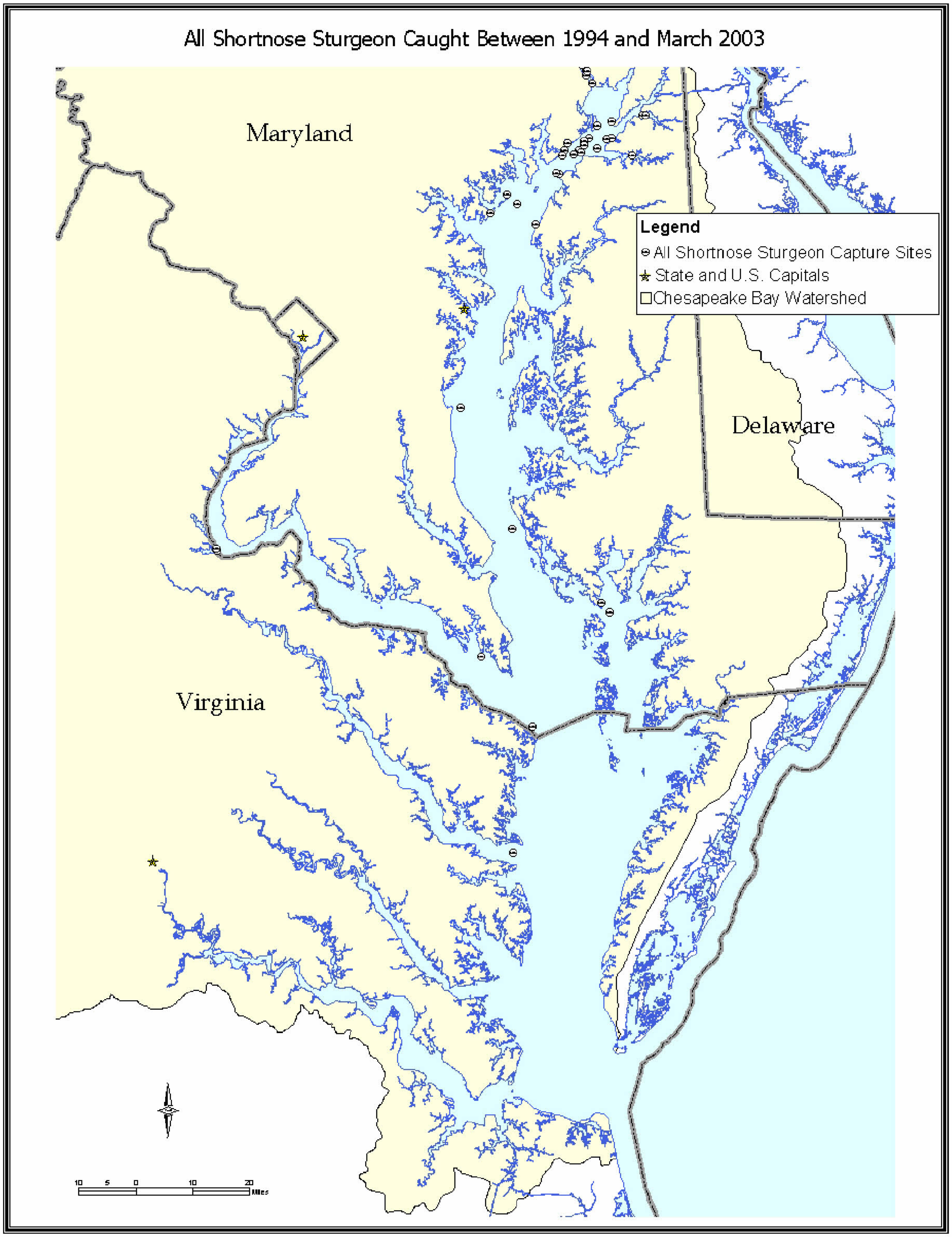

Figure 4. Map of all U.S. Fish and Wildlife Service sturgeon capture location stations where shortnose sturgeon were caught year-round between 1994-March 2003.

Sources: Mangold 2003, Spells 2003, Skjeveland et al. 2000.

showed reduced survival (~60 percent) at 13-15 ppt. At 96 hours exposure, 76 days old juveniles experienced complete mortality at 15 ppt. Yearlings (330 days old) exposed to 25 ppt showed 100 percent survival during an 18 hr trial, but were extremely stressed and probably would have succumbed past the experiment's end (Jenkins et al. 1993). No yearlings survived acute exposures to 30 or 35 ppt.

Niklitschek (2001), in dissertation research, exposed shortnose sturgeon juveniles (~6-12 months in age) to salinity conditions after more gradual periods of acclimation (1 ppt/day). In 10 day trials at 0 to 22 ppt, he observed comparatively lower growth and higher routine metabolism rates for shortnose sturgeon than Atlantic sturgeon. In spatially explicit habitat models, these bioenergetic differences contributed to habitat curtailments in lower tributaries and the mainstem of the Chesapeake Bay due to high salinity effects there. Salinity was predicted to be a chief factor contributing to lower (often negative) production of shortnose sturgeon in lower Chesapeake Bay habitats in comparison to tidal fresh habitats (<0.5 ppt) in the upper Chesapeake Bay and major tidal tributaries (e.g., Potomac, Rappahannock, James, and Nanticoke Rivers. In behavioral studies (Niklitschek 2001), juvenile shortnose sturgeon (as well as Atlantic sturgeon) did not discriminate between salinities of 0 and 8 ppt, nor did they exhibit preference between 8 and 15 ppt. Juvenile shortnose sturgeon showed a stressed behavioral response and reduced survival at 29 ppt in comparison to salinities 0, 8, 15, and 22 ppt.

Distribution Studies

Distribution studies and laboratory experiments support the view that shortnose sturgeon show preference for riverine and estuarine habitats over marine ones (e.g., Secor 2003). Shortnose adults have been reported occasionally in coastal waters up to 31 ppt, but typically occur within several kilometers of their natal estuaries (Dadswell et al. 1984; Kynard 1997). As an example, shortnose sturgeons recorded in Sandy Hook Bay are believed to be part of Hudson River population (Dadswell et al. 1984). Kynard (1997) described the life cycle of shortnose sturgeon as freshwater amphidromous, which specifies freshwater as spawning location but occasional forays into estuaries and coastal regions that are unrelated to spawning. This contrasts with the sympatric Atlantic sturgeon, which are considered true anadromous fishes that must migrate into coastal waters to complete their life cycles (Kynard 1997; Dovel and Berggren 1983; Dovel et al. 1992). Freshwater amphidromy has also been termed semi-anadromy, which also typifies the life cycle of Chesapeake Bay white perch.

The life cycle for shortnose sturgeon in regions north of South Carolina has been generalized by several authors (Dadswell et al. 1984; Bain 1997; Kynard 1997).

1. Adults move from brackish wintering grounds to head of estuary for spawning;

2. Adults feed in freshwater tidal portion during summer months and move back down estuary for winter; and

3. Juveniles disperse from tidal freshwater (where they originated) to brackish winter grounds during their first year of life.

In general, shortnose sturgeon do not invade salinities greater than 15 ppt, with centers of concentrations at less than 5 ppt for all life history stages during summer months (Dadswell et al.

1984; Brundage and Meadows 1982; Dovel et al. 1992; Geogehan et al. 1992; Collins and Smith 1996; Bain 1997; Haley 1999). There are at least two 'landlocked' populations of shortnose sturgeon that can complete their life cycles in freshwater – the Santee Cooper and Holyoke Pool sub-populations (Kynard 1997).

Kynard (1997) hypothesized that there occurred latitudinal trends in the propensity of individuals of a population to move outside the natal estuary into coastal waters. Fish from the most northerly populations (St. John River, New Brunswick) would emigrate into coastal regions during winter months to avoid stressful temperatures. Shortnose from systems between Merrimack River and Delaware Bay were the least likely to migrate to coastal waters since temperature conditions were favorable in these estuaries year-round. In systems from South Carolina to Florida (St. Johns Estuary), summer temperatures may drive shortnose adults to use down-estuary and coastal areas.

The issue of coastal occurrence of shortnose remains controversial. Past studies have misidentified Atlantic sturgeon juveniles as shortnose sturgeon (Kynard 1997). Physiological salinity limits on adult shortnose sturgeon are not fully understood at this time. Genetic evidence strongly indicates limited straying among natal estuaries (Wirgin et al. in press). Indeed, Kynard (1997) concludes, "The lack of marine movements by most adults suggests that the recolonization rate of shortnose…would be slow." Still, some records of shortnose in coastal waters (up to 31 ppt; Dadswell 1984) cannot be questioned. An interesting case in point is the recent 'invasion' of hatchery shortnose sturgeon stocked into the Savanna River yet recaptured in lower South Carolina estuaries (Smith et al. 2002). Clearly these fish must have left Savanna River and emigrated into waters that approached marine salinities in the inter-coastal waterway.

Chesapeake Bay Salinity Distributions

Maps of long-term averaged bottom salinity distributions document a lack of overlap of the preferred (<5 ppt) and a limited overlap with the likely upper salinity tolerance (<15 ppt) of shortnose sturgeon and deep-water and deep-channel designated use habitats during the summer months (figures 5, 6 and 7, respectively).

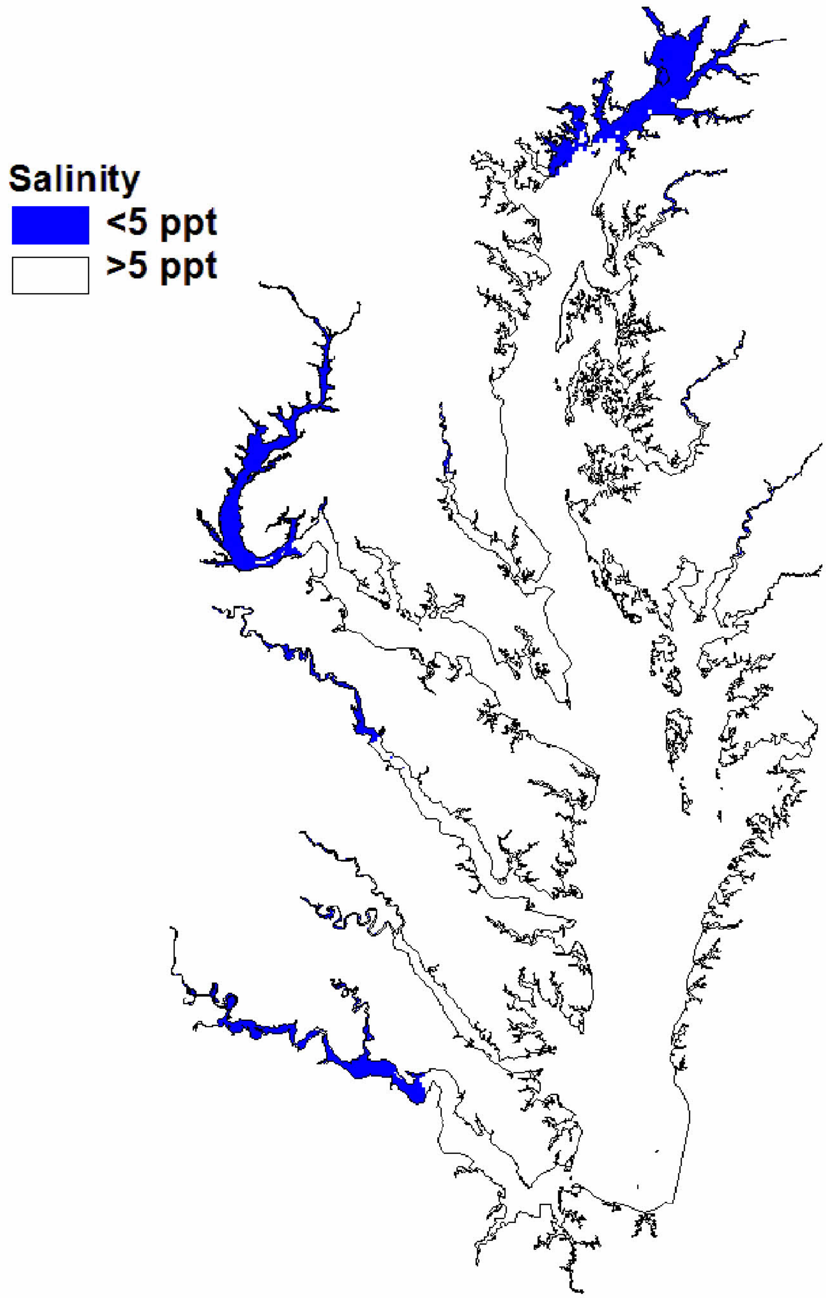

Figure 5. Map of summer averaged bottom water salinities <5 ppt based on Chesapeake Bay Water Quality Monitoring Program data from 1996-2000.

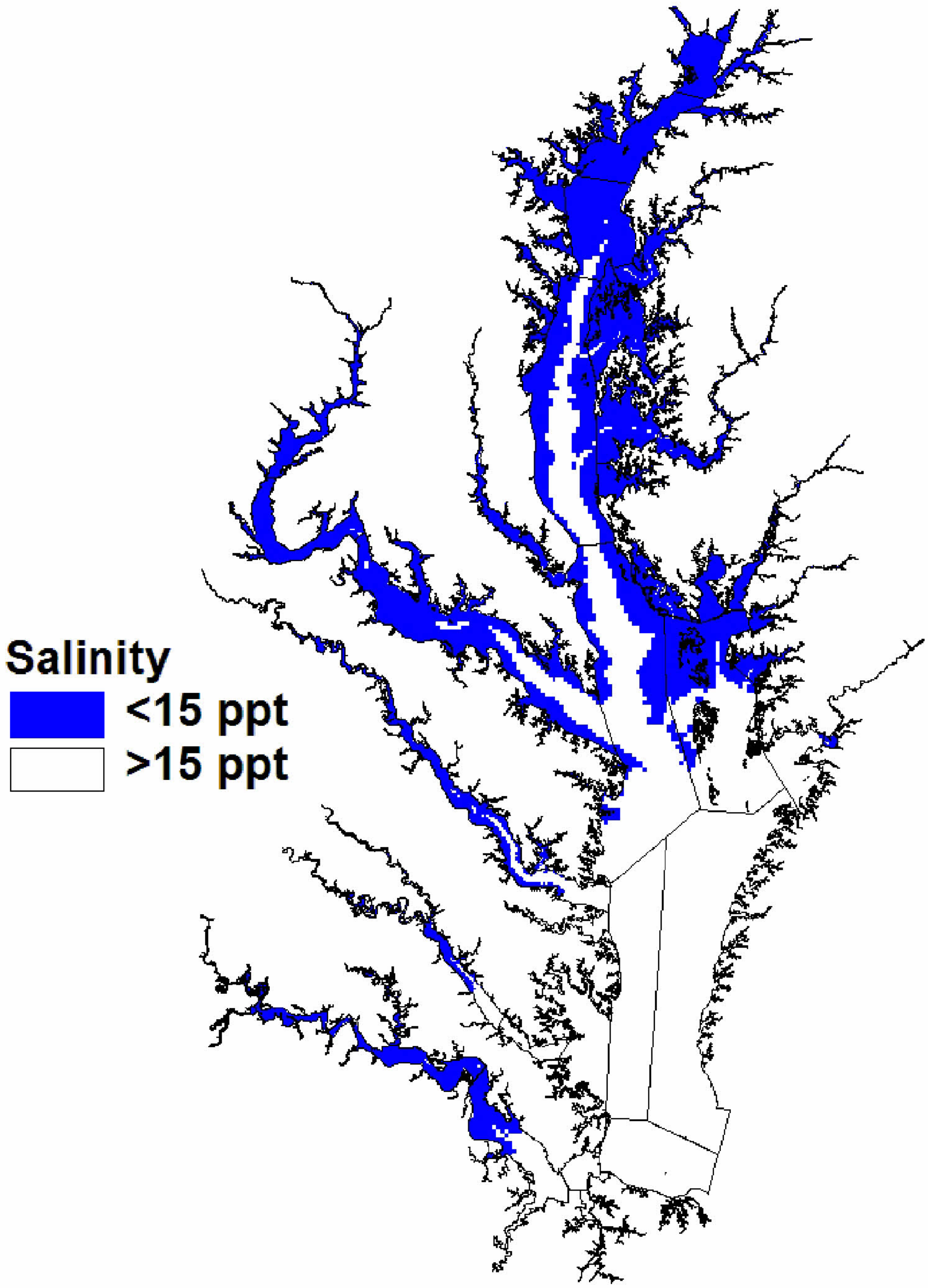

Figure 6. Map of summer averaged bottom water salinities <15 ppt based on Chesapeake Bay Water Quality Monitoring Program data from 1996-2000.

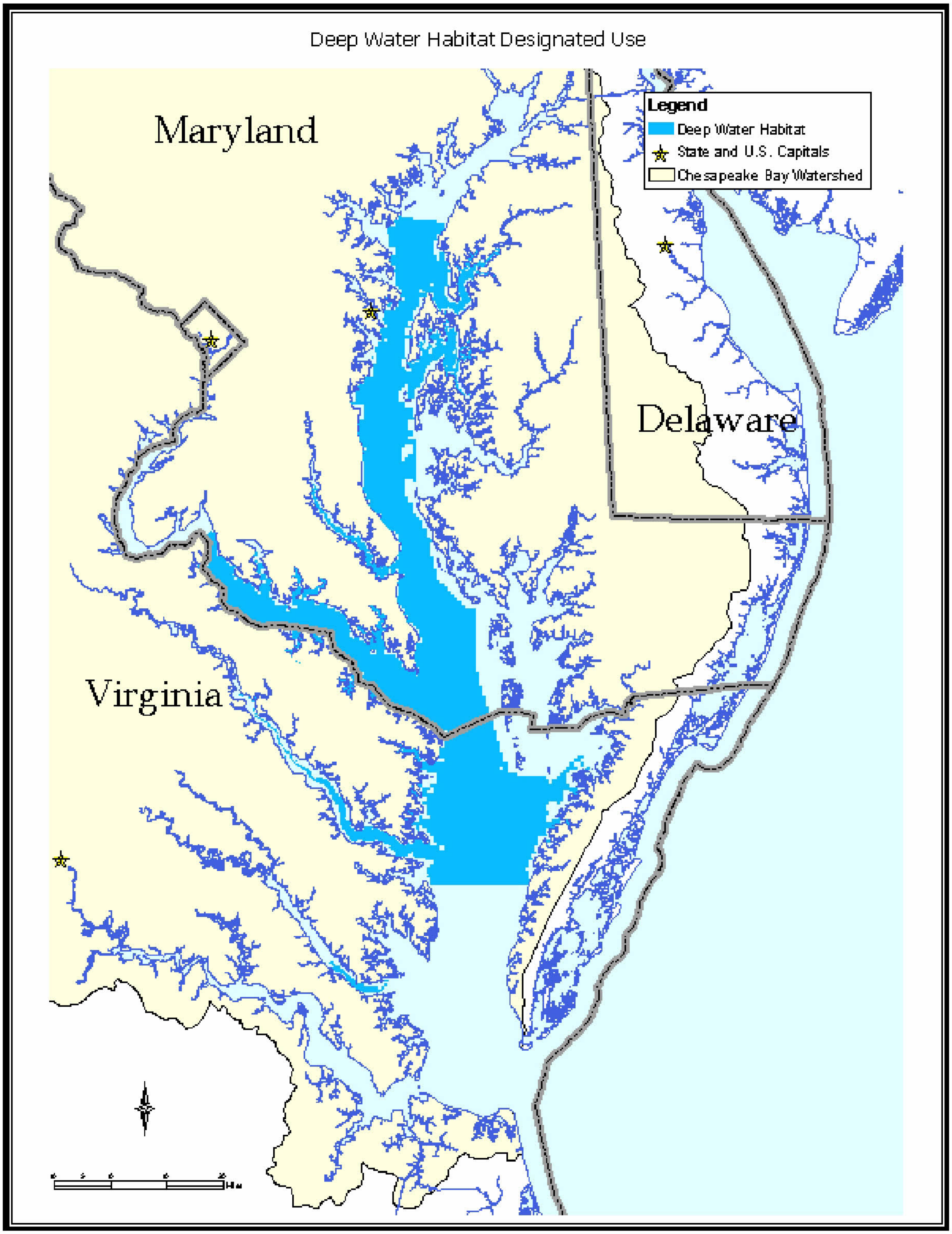

Figure 7. Long-term averaged spatial distribution of deep-water designated use habitats for comparison only with figures 5 and 6 salinity distributions. Actual deep-water designated use habitats will be determined based on month by month delineation of the pycnocline depths using Chesapeake Bay water quality monitoring cruise data.

Life History of Shortnose Sturgeon

Shortnose sturgeon are benthic fish that feed on a variety of benthic and epibenthic invertebrates including molluscs, crustaceans (amphipods, chironomids, isopods), and oligochaete worms (Vladykov and Greeley 1963; Dadswell 1979). Shortnose sturgeon are long-lived (30 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at 5 to 10 years, while females mature between 7 and 13 years.

In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding, and overwintering activities. In spring, as water temperatures rise above 8°C, pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas. Spawning occurs from mid/late March to mid/late May depending upon location. In populations that have free access to the total length of a river (e.g., no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah, Delaware, and Merrimack Rivers), spawning areas are located at the farthest accessible upstream reach of the river, often just below the fall line (NOAA National Marine Fisheries Service 1998a). Shortnose sturgeon spawn in upper, freshwater sections of rivers and feed and overwinter in both fresh and saline habitats. Shortnose sturgeon are believed to spawn at discrete sites within the river (Kieffer and Kynard 1996).

Adult shortnose sturgeon typically leave the spawning grounds soon after spawning. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell et al. 1984; Buckley and Kynard 1985; O'Herron et al. 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Young-of-the-year shortnose sturgeon are believed to move downstream after hatching but remain within freshwater habitats (Dovel 1981). Older juveniles tend to move downstream in fall and winter as water temperatures decline and the salt wedge recedes. Juveniles move upstream in spring and feed mostly in freshwater reaches during summer.

Shortnose sturgeon occur at depths between 1 and 12 meters (Kieffer and Kynard 1993; Savoy and Shake 2000: Welsh et al. 2000).

Status of Shortnose Sturgeon in the Chesapeake Bay

In the final recovery plan, the NOAA National Marine Fisheries Service identified 19 separate distinct populations occurring in New Brunswick Canada (1); Maine (2); Massachusetts (1); Connecticut (1); New York (1); New Jersey/Delaware (1); Maryland and Virginia (1); North Carolina (1); South Carolina (4); Georgia (4); and Florida (2) (NOAA National Marine Fisheries Service 1998a). The NOAA National Marine Fisheries Service stated that loss of a single shortnose sturgeon population segment may risk the permanent loss of unique genetic information that is critical to the survival and recovery of the species and that, therefore, each shortnose sturgeon population should be managed as a distinct population segment or recovery unit for the purposes of Section 7 of the Endangered Species Act (NOAA National Marine Fisheries Service 1998a). The NOAA National Marine Fisheries Service concluded in the Biological Opinion for the Washington Aqueduct Permit that because of this policy, actions that could adversely affect a DPS or recovery unit would be evaluated in terms of their potential to jeopardize the continued existence of an individual population segment (as opposed to the existence of shortnose sturgeon range-wide) (NOAA National Marine Fisheries Service 2002).

The NOAA National Marine Fisheries Service recovery plan indicates that shortnose sturgeon found in the Chesapeake Bay and its tributaries are considered part of the Chesapeake Bay distinct population segment. Welsh et al. (1999) summarizes historical and recent evidence of shortnose sturgeon presence in the Chesapeake Bay. The first published account of shortnose sturgeon in the Chesapeake system was an 1876 record from the Potomac River reported in a general list of fishes of Maryland (Uhler and Lugger 1876). Other historical records of shortnose sturgeon in the Chesapeake Bay as reviewed by Dadswell et. al. (1984) are not conclusive, as most likely these species were misidentified Atlantic sturgeon and possibly mis-identified tributaries as well (D. Secor, personal communication, 2003).

Delaware/Chesapeake Migratory Corridor

The issue of whether shortnose sturgeon naturally populates the Chesapeake Bay through local reproduction or immigration centers on the role of C&D Canal as a migration corridor. The Delaware population has long been noted for having a viable and moderately large shortnose sturgeon population. Brundage and Meadows (1982) reviewed all literature and reports for the period 1817-1979 and concluded that the center of distribution of adults during summer months was 1-3 ppt. For the more recent period 1973-1979, a small concentration of shortnose sturgeon was observed in proximity to the C&D Canal, prompting them to conclude that "...interchange between the two estuaries [Delaware and Chesapeake] would seem highly probable." Hastings et al. (1987), estimated a moderately large population (in comparison to Hudson River and St. John River Canada) of 6,000-14,000 sturgeons in the upper tidal estuary for the period 1981-1987. Several authors have speculated that the range of the Delaware population was probably contracted during much of 20th Century due to an anoxic/hypoxic zone of water occurring between Philadelphia and Wilmington (Brundage and Meadows 1982; Kynard 1997), but that recent improvements in water quality may have contributed to a range expansion into areas including the vicinity of C&D Canal. Kynard (1997) in particular, called attention to the likelihood that the C&D Canal may in recent times (since improvement in water quality and range expansion in the Delaware Bay) serve as a corridor for emigration by Delaware population shortnose sturgeon into the Chesapeake Bay.

In contrast to the Delaware Bay, there is little evidence that shortnose sturgeon occur in abundance in the Chesapeake Bay or in fact remain viable. In the early publication, *Fishes of Chesapeake Bay*, Hildebrand and Schroeder (1927), called into question whether shortnose sturgeon remained in the Chesapeake Bay and believed that the very rare observations of shortnose sturgeon in the 20th Century may have been due to taxonomic misidentifications. Modern ichthyologists continue to debate whether shortnose sturgeon historically occurred in Chesapeake Bay tributaries, or whether their abundances approached those observed elsewhere (J. Waldman, personal communication, 2003; J. Musick, personal communication, 2002).

It is unknown at this time whether there is a reproducing population of shortnose sturgeon in the Chesapeake Bay. Kynard (1997) suggests that no reproducing populations of shortnose sturgeon exist between the Delaware and Cape Fear estuaries, but may be related to shared qualities of the Chesapeake Bay and North Carolina estuaries including shallow water bathymetries (Paul 2001), large historical inputs of sediment and nutrients to these systems

(Cooper 1995; Brush 2001; Secor and Austin, in review), and the low volume of suitable spawning habitats (clean rubble, cobble and other substrate needed for egg attachment).

Dadswell et al. (1984) and Welsh et al. (2002) documented occurrence of shortnose sturgeon in the Chesapeake Bay in the vicinity of C&D Canal for the periods 1976-1981 and 1996-2001, respectively. Both these periods contained a set of anomalously wet years (http://md.water.usgs.gov/monthly/bay.html), which would be expected to favor emigration through the canal by Delaware population sturgeons. Further, an unusually strong spring freshet in 1996 altered salinity structure throughout most of the Chesapeake Bay for much of the spring and summer. This would have facilitated dispersal of shortnose sturgeon to regions away from the upper Chesapeake Bay (C&D Canal) and could account for recent occurrences in Potomac River.

The Federal Recovery Plan for Shortnose sturgeon (NOAA National Marine Fisheries Service 1998a) noted these post-1996 occurrences, and in a precautionary framework, used the occurrence data as evidence for listing the Chesapeake Bay as a Distinct Population Segment. Recent genetic data, however, indicates that shortnose sturgeons captured in the Chesapeake Bay since 1996 represent a sub-set of the Delaware Bay's gene pool (Wirgin et al., in review). If the Delaware population continues to expand in abundance and range, we should expect increased emigration of shortnose sturgeon through the C&D Canal and into other parts of the Chesapeake Bay, particularly in wet years.

Genetic Findings

Research conducted by the New York University School of Medicine involving mitochondrial DNA (mtDNA) analysis of shortnose sturgeon populations suggests that shortnose sturgeon captured in the upper Chesapeake Bay may have migrated from the Delaware River to the upper Chesapeake through the Chesapeake and Delaware Canal (Grunwald et al. 2002). In this study, genetic comparisons were made among all shortnose sturgeon populations for which tissue samples were available. All population comparisons exhibited clear and significant differences in haplotype frequencies except for comparisons between the Upper/Lower Connecticut River and Delaware/Chesapeake. There were no unique haplotypes in the Chesapeake Bay fish. Samples from four fish from the Potomac River were analyzed and results indicate that these fish exhibited the same haplotypes as fish found elsewhere in the Chesapeake Bay and in the Delaware River. These results suggest that some or all of the sturgeon captured in the Chesapeake Bay and its tributaries may not be part of the Chesapeake Bay, but rather transients from the Delaware population.

However, the Washington Aqueduct Permit biological opinion concluded that mitochondrial DNA (mtDNA) represents only a fraction (less than 1 percent) of the genetic material and is maternally inherited. Therefore, in order to obtain conclusive results, it is necessary to look at nuclear DNA (nDNA), which represents greater than 99 percent of the genetic material and is biparentally inherited (NOAA National Marine Fisheries Service 2002). In the absence of stronger evidence to the contrary, the NOAA National Marine Fisheries Service presumes that shortnose sturgeon captured in the Chesapeake Bay and its tributaries are part of the Chesapeake Bay distinct population segment (NOAA National Marine Fisheries Service 2002).

Field Study Results

The U.S. Fish and Wildlife Service conducted a sampling study sponsored by the U.S. Army Corps of Engineers between 1998 and 2000 in the Maryland waters of the Chesapeake Bay to determine the occurrence of shortnose and Atlantic sturgeon in areas of proposed dredge-fill operations (Skjeveland et. al. 2000). This study included fishing at a total of 24 sites within the Chesapeake Bay, five of which were located in the middle Potomac River approximately 30 to 74 miles downstream of the Washington Aqueduct discharge site. During this study, no shortnose sturgeon were captured in the Potomac or Susquehanna rivers. An additional study by the U.S. Fish and Wildlife Service was performed in the Potomac River and included sampling at two areas in the vicinity of Little Falls, Virginia, which are environments that are consistent with the preferred spawning habitat of shortnose sturgeon and are located near the Aqueduct discharge sites (Eyler et. al. 2000). No shortnose sturgeon were captured during this study either.

A separate U.S. Fish and Wildlife Service sampling study was also conducted in the upper Chesapeake Bay mainstem, lower Susquehanna River and Chesapeake/Delaware Canal during 1998 and 2000 in conjunction with a Section 7 consultation for the Baltimore Harbor and Channels Federal Navigation Project (as cited in NOAA National Marine Fisheries 2002). This study involved bottom gillnetting at 19 sites within the upper Chesapeake Bay mainstem and lower Susquehanna River, and tracking of sonically tagged sturgeon within the upper Bay and the Canal. No shortnose sturgeon were captured at any of the 19 sites. Figure 8 illustrates the gill netting sites from these three U.S. Fish and Wildlife Service studies where no sturgeon were caught.

The U.S. Fish and Wildlife Service Atlantic Sturgeon Reward Program has documented the incidental captures of 50 shortnose sturgeon from various locations in the Bay over the six year duration of the program (Mangold 2003; Spells 2003; Skjeveland et. al. 2000) (see Figure 4). The majority of these fish were tagged and tissue samples were taken from 36 fish in order to determine the genetic characteristics of the individuals. The shortnose sturgeon have been incidentally captured via this program from the lower Susquehanna River (4), the Bohemia River (2), Potomac River (6), south of the Bay Bridge near Kent Island (2), near Howell Point (1), just north of Hoopers Island (1), the Elk River (1) and Fishing Bay (2). The remaining 31 shortnose sturgeon were captured in the upper Bay north of Hart-Miller Island. These fish were captured alive in either commercial gillnets, poundnets, fykenets, eel pots, hoop nets, or catfish traps.

According to the NOAA National Marine Fisheries Service Washington Aqueduct Permit biological opinion, the U.S. Fish and Wildlife Service studies may not have been comprehensive enough to determine the presence or absence of sturgeon in the upper tidal Potomac River (NOAA National Marine Fisheries Service 2002). Sampling sites may have been too deep with too strong a current and timing and duration of the sampling events and the type of nets employed may not have been appropriate for targeting shortnose sturgeon (NOAA National Marine Fisheries Service 2002). This finding was reported at the same time as documenting no captures of shortnose sturgeon during a 2 year U.S. Fish and Wildlife Service bottom gill netting

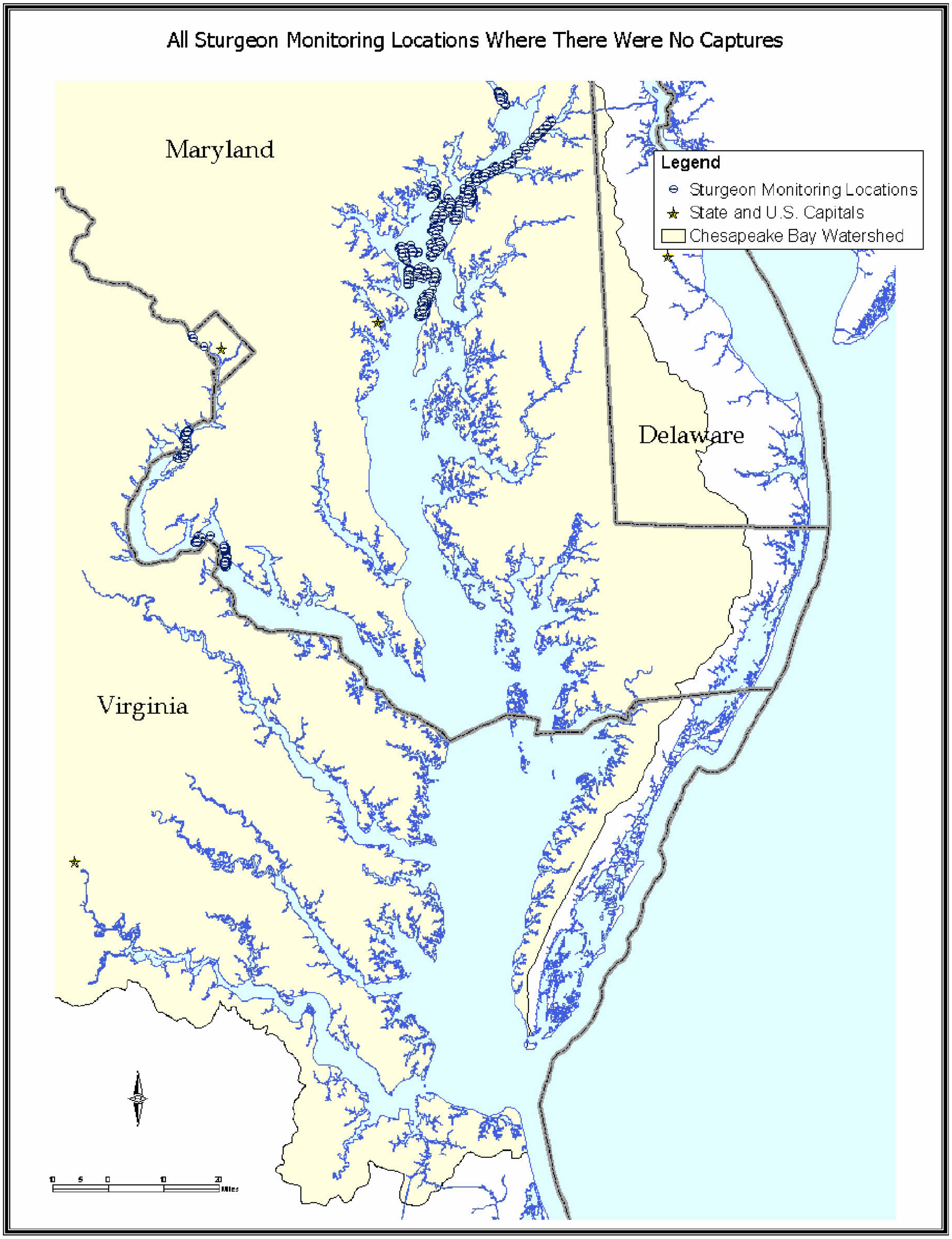

Figure 8. Locations of all the U.S. Fish and Wildlife Service fisheries-independent sturgeon sampling stations where no sturgeon were caught.

Source: Skjeveland et al. 2000.

study on the Potomac River which included a *total* of 4,590 fishing hours. Furthermore, it should be noted that it is the opinion of the National Marine Fisheries Service that the U.S. Fish and Wildlife Service studies should not be used as conclusive indicator of shortnose sturgeon absence in the upper tidal Potomac River (NOAA National Marine Fisheries Service 2002).

A 2000 NOAA National Marine Fisheries Service report, entitled "A Protocol for Use of Shortnose and Atlantic Sturgeons" identified a minimum sampling protocol for use in north central rivers (Chesapeake drainages to the Merrimack River) to confirm shortnose sturgeon presence or absence. The NOAA National Marine Fisheries Service Washington Aqueduct Permit biological opinion indicated that the U.S. Fish and Wildlife Service studies did not follow this desired protocol, which was published after the studies commenced. That report cited that the U.S. Fish and Wildlife Service sampling sites may have been too deep, in areas with too strong a current to adequately document the presence of shortnose sturgeon (NOAA National Marine Fisheries Service 2002). In addition, the timing and duration of the sampling events and the type of nets employed may not have been appropriate for targeting shortnose sturgeon habitat in question (NOAA National Marine Fisheries Service 2002).

Lacking conclusive data, the NOAA National Marine Fisheries Service's Washington Aqueduct Permit biological opinion assumed the presence of shortnose sturgeon based on the documented presence of this species and suitable spawning habitat in the Potomac River system. The NOAA biological opinion cited evidence from the life history attributes of shortnose sturgeon which suggests that fish from the Chesapeake Bay distinct population segment were also spawning in at least the Susquehanna, Gunpowder, and Rappahannock river systems (NOAA National Marine Fisheries Service 2002).

Habitat Quality Benefits from Dissolved Oxygen Criteria Attainment

Recent adoption of new Chesapeake Bay basinwide caps on nitrogen, phosphorus and sediment loads by all seven watershed jurisdictions–New York, Pennsylvania, Maryland, Virginia, West Virginia, Delaware and the District of Columbia–and the EPA will result in significant improvements in tidal water quality (U.S. Environmental Protection Agency 2003b). Restoration of sturgeon habitat is among the many benefits that will be achieved. Open-water designated use habitats currently unsuitable for sturgeon will be restored. Upon attainment of the 175 million pounds total nitrogen loading cap (110 million pound reduction from 2000 loads) and the 12.8 million pound total phosphorus loading cap (6.3 million pound reduction from 2000 loads), dissolved oxygen levels last observed in the 1950s and early 1960s will become the norm. Bay shorelines will likely see over 185,000 acres of underwater bay grasses, more than double the acreages mapped today.

The adoption of the new loading caps underscores the commitment of the Chesapeake Bay watershed partners to restoring the Bay. These loading caps are the greatest, most challenging and stringent that have ever been established. According to the Chesapeake Bay Commission's *The Cost of a Clean Bay*, the jurisdictions will need an additional 12.8 billion dollars to achieve these goals (Chesapeake Bay Commission 2003).

Attainment of these challenging yet feasible loading cap goals and the resultant restored water quality conditions will mean a substantial improvement to the Bay. Nevertheless, the seasonal designated deep-water and deep-channel habitats in the mesohaline Chesapeake Bay and lower rivers will still not be suitable for sturgeon during the summer months.

Recovery of the Shortnose Sturgeon

The Recovery Plan provides a strategy to protect shortnose sturgeon populations and habitats. The recovery outline includes three shortnose sturgeon recovery objectives: 1. Establishing Listing Criteria; 2. Protect Shortnose Sturgeon Population and Habitats; and 3. Rehabilitate Habitats and Population Segments (NOAA National Marine Fisheries 1998a). In addition to the *Regional Criteria Guidance* the Chesapeake Bay Program partners have been initiating programs and policies throughout the Chesapeake Bay, which incorporate many of the elements of the Rehabilitate Habitats and Population Segments recovery strategy. In fact, the partners spend millions of dollars a year on the restoration of the Bay. The *Chesapeake 2000*[5] agreement outlines some of these commitments which improve habitat for the Bay and are consistent with the Recovery Plan for the Shortnose Sturgeon. Some of these include:

- Restoring fish passage for migratory fish to more than 1,357 miles of currently blocked river habitat by 2003 and establishing monitoring program to assess outcomes;
- Work with local governments, community groups and watershed organizations to develop and implement locally supported watershed management plans in two-thirds of the watershed to address the protection, conservation and restoration of stream corridors, riparian forest buffers and wetlands for the purposes of improving habitat and water quality;
- Correct the nutrient- and sediment-related problems in the Chesapeake Bay and its tidal tributaries sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters under the Clean Water Act (the *Regional Criteria Guidance* is part of this commitment);
- Through continual improvement of pollution prevention measures and other voluntary means, strive for zero release of chemical contaminants from point sources, including air sources to the Bay;
- Ensure that measures are in place to meet our riparian forest buffer restoration goal of 2,010 miles by 2,010;
- Assess the effects of airborne nitrogen compounds and chemical contaminants on the Bay ecosystem and help establish reduction goals for these contaminants;
- Establish appropriate areas within the Chesapeake Bay and its tributaries as ‘no discharge zones’ for human waste from boats;
- Strengthen programs for land acquisition and preservation within each state that are supported by funding and target the most valued lands for protection;
- Reduce the rate of harmful sprawl development of forest and agricultural land in the Chesapeake Bay watershed by 30 percent;
- Make education and outreach a priority in order to achieve public awareness and personal involvement on behalf of the Bay and local watersheds.

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[5]The entire *Chesapeake 2000* agreement is available on the web at: www.chesapeakebay.net.

- Enhance funding for locally-based programs that pursue restoration and protection projects that will assist in the achievements of the goals of this and past agreement;

FINDINGS

The EPA has determined through consultation with the U.S. Fish and Wildlife Service and the NOAA National Marine Fisheries Service, that the only endangered or threatened species under the NOAA Fisheries jurisdiction in the evaluation area that will potentially be affected is the endangered **shortnose sturgeon** (*Acipenser brevirostrum*). All the other federal listed species within the Chesapeake Bay and its tidal tributaries would either not be affected or would be beneficially affected by the issuance of the *Regional Criteria Guidance*.

The EPA has determined that the recommended water clarity criteria will not likely adversely effect the listed species evaluated in this document. Furthermore, the EPA has determined that the proposed water clarity criteria will beneficially affect preferred habitat, spawning areas and food sources that the listed shortnose sturgeon depends on.

The EPA has determined that the recommended chlorophyll *a* criteria will not likely adversely affect the listed species evaluated in this document. Furthermore, the EPA has determined that the recommended chlorophyll *a* criteria will beneficially affect preferred habitat, spawning habitat and food sources that the listed species depends on.

The EPA has determined that the collective application of dissolved oxygen criteria for the migratory fish spawning and nursery and open-water fish and shellfish designated uses are fully protective of shortnose sturgeon survival and growth for all life stages.

- The migratory spawning and nursery 6 mg liter^{-1} 7-day mean and 5 mg liter^{-1} instantaneous minimum criteria will fully protect spawning shortnose sturgeon. The February 1 through May 31 application period for the migratory spawning and nursery criteria fully encompasses the mid-March through mid-May spawning season documented previously from the scientific peer reviewed literature.
- The individual components of the open water criteria protect shortnose sturgeon growth (5 mg liter^{-1} 30-day mean), larval recruitment (4 mg liter^{-1} 7-day mean) and survival (3 .2 mg liter^{-1} instantaneous minimum). A 4.3 mg liter^{-1} instantaneous minimum criterion applies to open waters with temperatures above 29°C considered stressful to shortnose sturgeon.
- The open water criteria applied to tidal fresh waters includes a 5.5 mg liter^{-1} 30-day mean criterion providing extra protection of shortnose sturgeon juveniles inhabiting tidal freshwater habitats.

The EPA has determined that adoption of the proposed dissolved oxygen criteria into Maryland, Virginia, Delaware and the District of Columbia's state water quality standards and their eventual attainment will beneficially affect shortnose sturgeon spawning, nursery, juvenile and adult habitats and food sources by driving widespread nutrient reduction loading actions leading to increasing existing ambient dissolved oxygen concentrations. This determination is consistent with and pursuant to Endangered Species Act provisions that state that the EPA is to use its authority to further the purpose of protecting threatened and endangered species (see 16 U.S.C. § 1536(a)). It is also consistent with the NOAA National Marine Fisheries Recovery Plan (1998a) for shortnose sturgeon which recommends working cooperatively with states to promote increased state activities to promote best management practices to reduce non-point sources.

The EPA has determined that adoption, implementation and eventual full attainment of the states adopted dissolved oxygen water quality standards will result in significant improvements in dissolved oxygen concentration throughout the tidal waters to levels last observed consistently over four to five decades ago in Chesapeake Bay and its tidal tributaries.

The EPA recognizes that dissolved oxygen criteria for June through September for the deep-water seasonal fish and shellfish and the deep-channel designated use are at or below levels that protect shortnose sturgeon. The EPA believes there are strong lines of evidence that shortnose sturgeon historically have not used deep-water and deep-channel designated use habitats during the summer months due to naturally pervasive low dissolved oxygen conditions.

- Published findings in the scientific literature regarding salinity preferences (tidal fresh to 5 ppt) and salinity tolerances (<15 ppt) clearly indicate shortnose sturgeon habitats are unlikely to overlap with the higher salinity deep-water and deep-channel designated use habitats.
- The EPA has concluded, based on extensive published scientific findings and in-depth analysis of the 1400 record U.S. Fish and Wildlife Service Reward Program database, that these same deep-water and deep-channel regions have not served as potential habitats for sturgeon during the June through September time period when there is a natural tendency for low dissolved oxygen conditions to occur.
- The EPA recognizes the potential limitations of the U.S. Fish and Wildlife Service data set. However, the EPA believes the significant extent of the capture records–400 stations and 1400 individuals caught–provides substantial evidence for the lack of a potential conflict between shortnose habitat and seasonally applied deep-water and deep-channel designated uses.

The EPA had determined that the recommended dissolved oxygen criteria for the refined designated uses will not likely adversely effect the listed species evaluated in this document. Furthermore, the EPA has determined that the Chesapeake Bay dissolved oxygen criteria will beneficially affect critical habitat and food sources that the listed species is dependent on.

SUMMARY AND CONCLUSION

Shortnose sturgeon are endangered throughout their entire range (NOAA National Marine Fisheries Service 2002). According to NOAA, in the Final Biological Opinion for the Washington Aqueduct, this species exists as 19 separate distinct population segments that should be managed as such; specifically, the extinction of a single shortnose sturgeon population risks permanent loss of unique genetic information that is critical to the survival and recovery of the species (NOAA National Marine Fisheries Service 2002). The shortnose sturgeon residing in the Chesapeake Bay and its tributaries form one of the 19 distinct population segments.

Adult shortnose sturgeon are present in the Chesapeake Bay based on the 50 captures via the U.S. Fish and Wildlife Service Atlantic Sturgeon Reward Program. However, the presence and abundance of all life stages within the evaluation area itself are unknown. Preliminary published scientific evidence suggests that the shortnose sturgeon captured in the Chesapeake Bay may be part of the Delaware distinct population segment using the C & D Canal as a migratory passage. However, the NOAA National Marine Fisheries Service recommend more studies utilizing nuclear DNA need to be conducted before this can be proven conclusively.

Section 9 of the Endangered Species Act and Federal regulations pursuant to section 4(d) of the Endangered Species Act prohibit the take of endangered and threatened species, respectively, without special exemption. 'Take' is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NOAA National Marine Fisheries Service to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Harass is defined by U.S. Fish and Wildlife Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

The Shortnose Sturgeon Recovery Plan (NOAA National Marine Fisheries Service 1998a) further identifies habitat degradation or loss (resulting, for example, from dams, bridge construction, channel dredging, and pollutant discharges) and mortality (resulting, for example, from impingement on cooling water intake screens, dredging and incidental capture in other fisheries) as principal threats to the species' survival. The recovery goal is identified as delisting shortnose sturgeon populations throughout their range, and the recovery objective is to ensure that a minimum population size is provided such that genetic diversity is maintained and extinction is avoided.

Considering the nature of the proposed *Regional Criteria Guidance*, the effects of the recommended criteria, and future cumulative effects in the evaluation area, the proposed issuance of *Regional Criteria Guidance* is not likely to adversely affect the reproduction, numbers, and distribution of the Chesapeake Bay distinct population segment in a way that appreciably reduces their likelihood of survival and recovery in the wild. This contention is based on the following: (1) the adoption of the recommended dissolved oxygen criteria into state water quality standards and subsequent attainment upon achievement of the Chesapeake Bay watershed's nutrient loading caps will provide for significant water quality improvements to the tributaries to the Chesapeake Bay (such as the Susquehanna, Gunpowder, and Rappahannock rivers) where the shortnose sturgeon would most likely spawn and spend their first year of life; (2) the main channel of the Chesapeake Bay most likely experienced reductions in dissolved oxygen before large-scale post-colonial land clearance took place, due to natural factors such as climate-driven variability in freshwater inflow; and (3) there is strong evidence that shortnose sturgeon have historically not used deep-water and deep-channel designated use habitats during the summer months due to naturally pervasive low dissolved oxygen conditions.

Based on the evaluation conducted in this document it is the EPA's conclusion that the proposed issuance of the *Regional Criteria Guidance* would not adversely affect the continued existence of the Chesapeake Bay DPS of shortnose sturgeon. No critical habitat has been designated for this species, and therefore, none will be affected. In fact, the EPA believes state adoption of the criteria into water quality standards will directly lead to increased levels of suitable habitat for shortnose sturgeon.

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APPENDICES

Appendix A *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll* a *for the Chesapeake Bay and Its Tidal Tributaries*.

Appendix B *Technical Support Document for the Identification of Chesapeake Bay Designated Uses and Attainability*.

Appendix C. List of Federally Endangered Species for Maryland, Virginia, Delaware and the District of Columbia.

APPENDIX C

Endangered Species in Maryland, Delaware, Virginia, and the District of Columbia.

Listings by State and Territory as of October 24, 2002

Notes:
Displays one record per listing entity.
Includes experimental populations and similarity of appearance species.
Pertains to the range of a species, not the listing status within a State/Territory.
Includes non-nesting sea turtles and whales in State/Territory coastal waters.
Includes species under the sole jurisdiction of the National Marine Fisheries Service.

Source : U.S. Fish and Wildlife website http://ecos.fws.gov/webpage/

Maryland – 26 listings

Animals – 19

Status	Listing
E	Bat, Indiana (*Myotis sodalis*)
E	Darter, Maryland (*Etheostoma sellare*)
T	Eagle, bald (lower 48 States) (*Haliaeetus leucocephalus*)
T	Plover, piping (except Great Lakes watershed) (*Charadrius melodus*)
E	Puma, eastern (*Puma concolor couguar*)
T	Sea turtle, green (except where endangered) (*Chelonia mydas*)
E	Sea turtle, hawksbill (*Eretmochelys imbricata*)
E	Sea turtle, Kemp's ridley (*Lepidochelys kempii*)
E	Sea turtle, leatherback (*Dermochelys coriacea*)
T	Sea turtle, loggerhead (*Caretta caretta*)
E	Squirrel, Delmarva Peninsula fox (*Sciurus niger cinereus*)
E	Sturgeon, shortnose (*Acipenser brevirostrum*)
T	Tiger beetle, northeastern beach (*Cicindela dorsalis dorsalis*)
T	Tiger beetle, Puritan (*Cicindela puritana*)
T	Turtle, bog (northern) (*Clemmys muhlenbergii*)
E	Wedgemussel, dwarf (*Alasmidonta heterodon*)
E	Whale, finback (*Balaenoptera physalus*)
E	Whale, humpback (Megaptera novaeangliae)
E	Whale, right (*Balaena glacialis*)

Plants – 7

Status	Listing
T	Joint-vetch, sensitive (*Aeschynomene virginica*)
E	Gerardia, sandplain (*Agalinis acuta*)
T	Amaranth, seabeach (*Amaranthus pumilus*)
T	Pink, swamp (*Helonias bullata*)

E	Dropwort, Canby's (*Oxypolis canbyi*)
E	Harperella (*Ptilimnium nodosum*)
E	Bulrush, Northeastern (*Scirpus ancistrochaetus*)

Virginia – 70 listings

Animals – 56

Status	Listing
E	Bat, gray (*Myotis grisescens*)
E	Bat, Indiana (*Myotis sodalis*)
E	Bat, Virginia big-eared (*Corynorhinus (=Plecotus) townsendii virginianus*)
XN	Bean, Cumberland (pearlymussel) AL; free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL (*Villosa trabalis*)
E	Bean, purple (*Villosa perpurpurea*)
E	Blossom, green (pearlymussel) (*Epioblasma torulosa gubernaculum*)
T	Chub, slender (*Erimystax cahni*)
T	Chub, spotfin (*Cyprinella monacha*) – Entire
E	Combshell, Cumberlandian (*Epioblasma brevidens*) – Entire Range; except where listed as Experimental Populations
XN	Combshell, Cumberlandian AL; free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL (*Epioblasma brevidens*)
E	Darter, duskytail (*Etheostoma percnurum*) – Entire Range
T	Eagle, bald (*Haliaeetus leucocephalus*) – Lower 48 States
E	Fanshell (*Cyprogenia stegaria*)
E	Isopod (*Lirceus usdagalun*) – Lee County cave
T	Isopod, Madison Cave (*Antrolana lira*)
E	Logperch, Roanoke (*Percina rex*)
XN	Madtom, yellowfin (*Noturus flavipinnis*) – Holston River, VA, TN
T	Madtom, yellowfin (*Noturus flavipinnis*) – Except where XN
E	Monkeyface, Appalachian (pearlymussel) (*Quadrula sparsa*)
E	Monkeyface, Cumberland (pearlymussel) (*Quadrula intermedia*) – Entire Range; except where listed as Experimental Populations
XN	Monkeyface, Cumberland (pearlymussel) (*Quadrula intermedia*) AL; Free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL
E	Mucket, pink (pearlymussel) (*Lampsilis abrupta*)
E	Mussel, oyster (*Epioblasma capsaeformis*)– Entire Range; except where listed as Experimental Populations
XN	Mussel, oyster (*Epioblasma capsaeformis*) AL; Free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL
E	Pearlymussel, birdwing (*Conradilla caelata*) – Entire Range; except where listed as Experimental Populations

E	Pearlymussel, cracking (*Hemistena lata*) – Entire Range; except where listed as Experimental Populations
E	Pearlymussel, dromedary (*Dromus dromas*) – Entire Range; except where listed as Experimental Populations
E	Pearlymussel, littlewing (*Pegias fabula*)
E	Pigtoe, finerayed (*Fusconaia cuneolus*) – Entire Range; except where listed as Experimental Populations
XN	Pigtoe, finerayed (*Fusconaia cuneolus*) AL; free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL
E	Pigtoe, rough (Pleurobema plenum)
E	Pigtoe, shiny Entire Range; Except where listed as experimental populations (*Fusconaiacor*)
XN	Pigtoe, shiny (*Fusconaia cor*) – AL; free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL
T	Plover, piping (*Charadrius melodus*) – Except Great Lakes watershed
E	Puma, eastern (*Puma concolor couguar*)
E	Rabbitsfoot, rough (*Quadrula cylindrica strigillata*)
E	Riffleshell, tan (*Epioblasma florentina walkeri* (E. walkeri))
E	Salamander, Shenandoah (*Plethodon shenandoah*)
T	Sea turtle, green (*Chelonia mydas*) – Except where endangered
E	Sea turtle, hawksbill (*Eretmochelys imbricata*)
E	Sea turtle, Kemp's ridley (*Lepidochelys kempii*)
E	Sea turtle, leatherback (*Dermochelys coriacea*)
T	Sea turtle, loggerhead (*Caretta caretta*)
E	Snail, Virginia fringed mountain (*Polygyriscus virginianus*)
E	Spinymussel, James (*Pleurobema collina*)
E	Squirrel, Delmarva Peninsula fox (*Sciurus niger cinereus*) – Except Sussex County, Delaware
E	Squirrel, Virginia northern flying (*Glaucomys sabrinus fuscus*)
E	Sturgeon, shortnose (*Acipenser brevirostrum*)
E	Tern, roseate (*Sterna dougallii dougallii*) – Northeast U.S. nesting population
T	Tiger beetle, northeastern beach (*Cicindela dorsalis dorsalis*)
T(S/A)	Turtle, bog (Muhlenberg) (southern) (*Clemmys muhlenbergii*)
E	Wedgemussel, dwarf (*Alasmidonta heterodon*)
E	Whale, finback (*Balaenoptera physalus*)
E	Whale, humpback (*Megaptera novaeangliae*)
E	Whale, right (*Balaena glacialis* [incl. *Australis*])
E	Woodpecker, red-cockaded (*Picoides borealis*)

Plants – 14

Status	Listing
T	Joint-vetch, sensitive (*Aeschynomene virginica*)
T	Amaranth, seabeach (*Amaranthus pumilus*)
E	Rock-cress, shale barren (*Arabis serotina*)

T	Birch, Virginia round-leaf (*Betula uber*)
E	Bittercress, small-anthered (*Cardamine micranthera*)
E	Coneflower, smooth (*Echinacea laevigata*)
T	Sneezeweed, Virginia (*Helenium virginicum*)
T	Pink, swamp (*Helonias bullata*)
E	Mallow, Peter's Mountain (*Iliamna corei*)
T	Pogonia, small whorled (*Isotria medeoloides*)
T	Orchid, eastern prairie fringed (*Platanthera leucophaea*)
E	Sumac, Michaux's (*Rhus michauxii*)
E	Bulrush, Northeastern (*Scirpus ancistrochaetus*)
T	Spiraea, Virginia (*Spiraea virginiana*)

District of Columbia – 3 listings

Animals – 3

Status	Listing
E	Amphipod, Hay's Spring (*Stygobromus hayi*)
T	Eagle, bald (lower 48 States) (*Haliaeetus leucocephalus*)
E	Puma, eastern (*Puma concolor couguar*)

Plants – 0

Delaware – 19 listings

Animals – 15

Status	Listing
T	Eagle, bald (*Haliaeetus leucocephalus*) – Lower 48 States
T	Plover, piping (*Charadrius melodus*)
E	Puma, eastern (*Puma concolor couguar*)
T	Sea turtle, green (*Chelonia mydas*) – Except where endangered
E	Sea turtle, hawksbill (*Eretmochelys imbricata*)
E	Sea turtle, Kemp's ridley (*Lepidochelys kempii*)
E	Sea turtle, leatherback (*Dermochelys coriacea*)
T	Sea turtle, loggerhead (*Caretta caretta*)
E	Squirrel, Delmarva Peninsula fox (*Sciurus niger cinereus*) – except Sussex County, Delaware
XN	Squirrel, Delmarva Peninsula fox [XN] (*Sciurus niger cinereus*)
E	Sturgeon, shortnose (*Acipenser brevirostrum*)
T	Turtle, bog (northern) (*Clemmys muhlenbergii*)
E	Whale, finback (*Balaenoptera physalus*)
E	Whale, humpback (*Megaptera novaeangliae*)
E	Whale, right (*Balaena glacialis*)

Plants – 4

Status	Listing
T	Pink, swamp (*Helonias bullata*)
T	Pogonia, small whorled (*Isotria medeoloides*)
E	Dropwort, Canby's (*Oxypolis canbyi*)
T	Beaked-rush, Knieskern's (*Rhynchospora knieskernii*)
T	Sea turtle, green (*Chelonia mydas*) – Except where endangered
E	Sea turtle, hawksbill (*Eretmochelys imbricata*)
E	Sea turtle, Kemp's ridley (*Lepidochelys kempii*)
E	Sea turtle, leatherback (*Dermochelys coriacea*)
T	Sea turtle, loggerhead *(Caretta caretta*)
E	Whale, finback (*Balaenoptera physalus*)
E	Whale, humpback (*Megaptera novaeangliae*)
E	Whale, right (*Balaena glacialis*)
E	Sturgeon, shortnose (*Acipenser brevirostrum*)